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UNITED STATES DEPARTMENT OF AGRICULTURE
BULLETIN No. 891
Contribution from the Bureau of Entomology
L. O. HOWARD, Chief

Washington, D. C. PROFESSIONAL PAPER July 28, 1922

THE GREEN JUNE BEETLE

By

F. H. CHITTENDEN, Entomologist in Charge, and
D. E. FINK, Entomological Assistant, Truck
Crop Insect Investigations

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THE GREEN JUNE BEETLE.[1]

By F. H. CHITTENDEN, *Entomologist in Charge*, and D. E. FINK, *Entomological Assistant, Truck Crop Insect Investigations.*[2]

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INTRODUCTION.

The green June beetle is one of the best known of Southern insects and is quite common in the Eastern States from New Jersey and southern Illinois southward. It occurs also somewhat commonly on Long Island, in southern Connecticut, and in the neighborhood of New York City. Injuries by this insect were at one time erroneously believed to be practically confined to the beetle, since the larvæ feed normally and largely on humus or mold, or soil rich in decaying vegetable matter, and in stable and lot manure.

The beetles injure fruits of various kinds, including grapes, peaches, raspberry, blackberry, apple, pear, quince, plum, prune, apricot, and nectarine, and frequently obtain nourishment as well on the sap of oak, maple, and other trees, and on the growing ears of

[1] *Cotinis nitida* L. (formerly known as *Allorhina nitida*); family Scarabaeidae, order Coleoptera.

[2] Investigations of the life history and habits have been conducted by the junior author in tidewater Virginia, and by the senior author in the District of Columbia and near-by points in northern Virginia. Similar investigations have been conducted by Mr. J. J. Davis, Bureau of Entomology, at Louisville, Ky., La Fayette, Ind., and elsewhere, and by Mr. Philip Luginbill, Cereal and Forage Insect Investigations, at Columbia, S. C. Many of the notes on injuries and habits made by these observers have been used in the preparation of this publication.

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corn. The beetle has been observed also eating a fungus on quince trees.

Indirectly the larvæ or grubs are responsible for considerable injury on the grounds of golf clubs and on lawns. They injure also corn, oats, sorghum, and alfalfa. Vegetables of many kinds are frequently attacked and injuries have been reported to celery, parsley, beets, turnip, lettuce, endive, strawberry, eggplant, potato, beans, carrot, parsnip, collards, peas, and other plants. Among ornamental plants, dahlia, rose, violet, geranium, hyacinth, and privet are attacked. The larvæ attack other forms of plants with comparatively succulent herbaceous stalks, and such crops as melons, tomato, and young sweet corn. The natural food plants are undoubtedly different varieties of grasses, cultivated forms, including bluegrass, evidently being more affected than those which are allowed to grow wild and become weedy.

The life history of the green June beetle has not hitherto been followed out. Many interesting facts have been learned in regard to its habits in its active stages, and an account of its natural enemies and other data have been brought together, thus adding much to our hitherto meager knowledge of its life economy. There is no longer any doubt that the insect is more injurious in its larval stages than as a beetle. Indeed the species does far more injury to vegetable and truck crops, according to records which have been made, than to fruits.

CLASSIFICATION.

The genus to which this species belongs is a member of the tribe Cetoniini, of the family Scarabaeidae, in which the epimera of the mesothorax are visible from above. A subtribe of the same name has the elytra sinuate on the sides, and the mesosternum always prominent. The mandibles are feeble, in great part membranous, and the last spiracle is situated midway between the anterior and posterior margins of the segment. The prothorax is lobed at the base, covering the scutellum. The genus Cotinis may further be separated from related genera in having the clypeus armed with a short horn, which is more prominent in the male.

According to Bates (16)[3] the North American species classified under the genus Allorhina are placed in the genus Cotinis of Burmeister (1842). What Bates (16, p. 345–346) says in regard to *C. mutabilis* and *C. sobrina* is well worth quoting in this connection as bearing about equally well upon the relationship of *mutabilis* and *nitida*. He writes:

> After careful examination of about 250 examples I have come to the conclusion that the characters adduced by Burmeister to distinguish this species

[3] Figures in parentheses refer to "Literature cited," p. 49.

from *C. sobrina* are in the highest degree inconstant, and that there are no means of defining the two species. All that can be said is that *C. mutabilis* is, in the great majority of its individuals, larger and broader. The shape of the clypeal horn is very variable, and its varieties do not correspond with variations in size, breadth, and color, large and robust specimens of the typical *mutabilis* having the horn either dilated toward the apex, parallel-sided, or triangular, and the same diversities may be seen in small and slender oblong examples of *C. sobrina*. It is the same with regard to form and color; for it is far from the case that the large and broad examples (*C. mutabilis*) only are unicolorous; smaller and narrower individuals exist equally unicolorous and of nearly all the color-varieties displayed by the larger set. It is true that the variegated varieties described by Burmeister under *C. sobrina* are, as a rule, smaller than the others; but they are connected by the most finely graduated series of variations, so that it is impossible to draw a distinction between the two series. The case is a very difficult one to deal with. It would not be satisfactory, and scarcely practicable, to include under one specific diagnosis all the numerous varieties, some of which are possibly local, thus presenting an interesting study to future collectors and students; the better course seems to be to treat the more distinct separately, giving the localities of each.

DESCRIPTIVE.

The beetle (fig. 1) is larger and more robust than the common brown May and June beetles (Phyllophaga), measuring from three-fourths to a full inch or more in length, and about one-half inch wide. The color varies from dull brown with irregular stripes of green to beautiful uniform velvet green, the margins of the body being usually light brown varying to orange yellow. The lower surface is metallic greenish or yellow, or metallic dark brown with a yellow-green tinge.

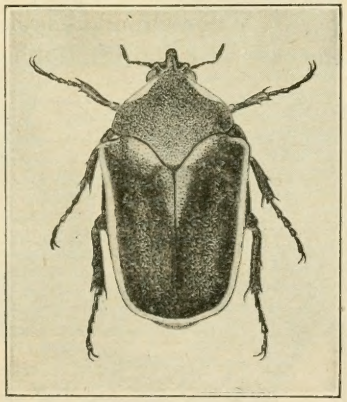


FIG. 1.—Adult of green June beetle (*Cotinis nitida*) of a type showing narrow margin about elytra and narrow margin on anterior half of thorax. One-third enlarged.

The full-grown larva is illustrated in figure 2 and Plate II. When compared with that of Phyllophaga (fig. 3), it will be noticed that the former is stouter with shorter legs.

The pupa, which is also stouter, is shown alone and within its pupal case or cocoon in Plate III, A, B. The pupa of Phyllophaga (Pl. III, C) differs from the pupa of Cotinis in that the pupa of the former is not encased in a regular cocoon.

HABITS DIFFERENT FROM THOSE OF WHITE GRUBS.

The green June beetle differs from the May beetles in habits, being strictly diurnal and most active in the heat of the day, whereas

the typical winged Phyllophaga is nocturnal. There is a still more striking difference in that the larva of the green June beetle travels on its back, whereas that of Phyllophaga either progresses on its side or, where possible, on the abdomen with the aid of the legs.

The larva (fig. 2), particularly when mature, differs from the common white grub of the genus Phyllophaga in being larger, and pro-

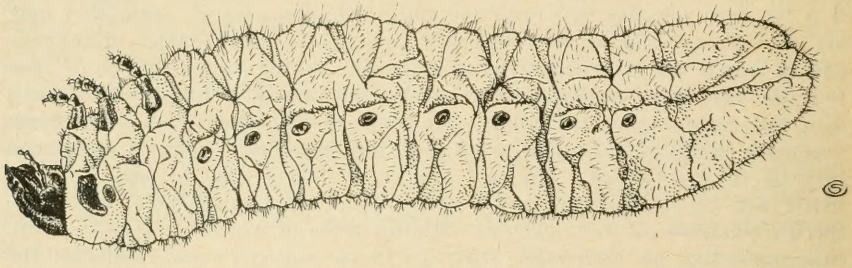


FIG. 2.—Full-grown larva of green June beetle in natural position crawling on its back. Twice natural size.

portionately so, as regards the size of the adults. It is also more robust and more nearly cylindrical; its legs are considerably shorter and its mandibles and other mouth parts smaller. It differs also in the possession of stiff ambulatory bristles, which more or less closely cover the dorsum and enable the insect to crawl, not on its side, as is the case with the Phyllophaga larva, but upon its back. This is accomplished by alternate contraction and expansion of the segments of the body, the stiff dorsal hairs materially assisting progress. The speed is probably more rapid than that of any other known genus of the Scarabaeidae occurring in the United States. Indeed, it progresses on its back at about the same rate as the hairy caterpillars do on their legs and prolegs, and in a similar manner.

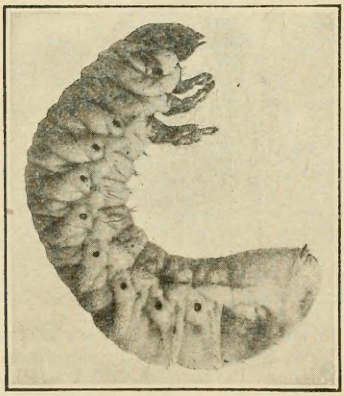
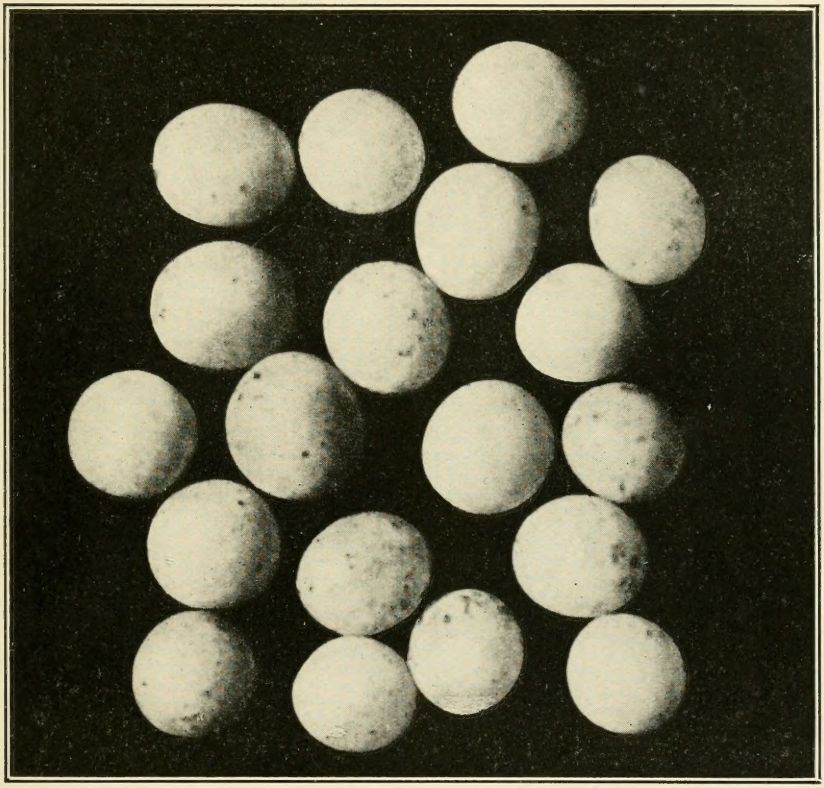


FIG. 3.—True white grub (*Phyllophaga* sp.) which does not crawl on its back. Enlarged. Compare with figure 2.

TECHNICAL DESCRIPTION.

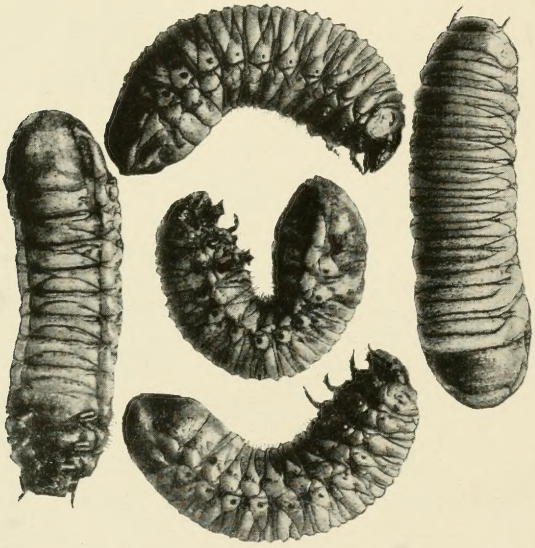
THE BEETLE.

The beetle of *Cotinis nitida* is related, although rather distantly, to the brown May or June beetles of the North, belonging to a different group of the Scarabaeidae—the Cetoniini. The appearance is quite different. It is variable as to color, but is usually a beautiful velvety



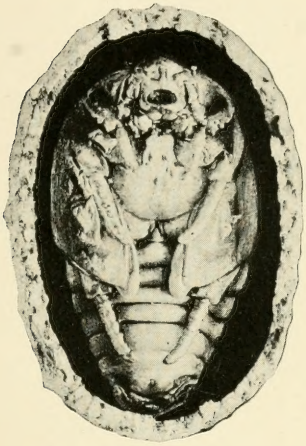
GREEN JUNE BEETLE.

Eggs, highly magnified.



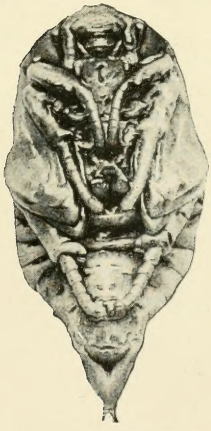
GREEN JUNE BEETLE.

Full-grown larvæ of green June beetle (*Cotinis nitida*), actual size.



A

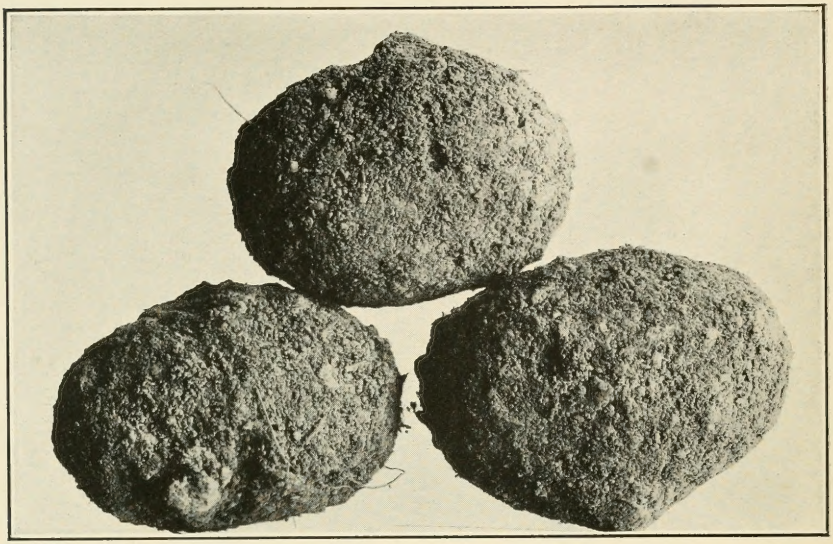
B



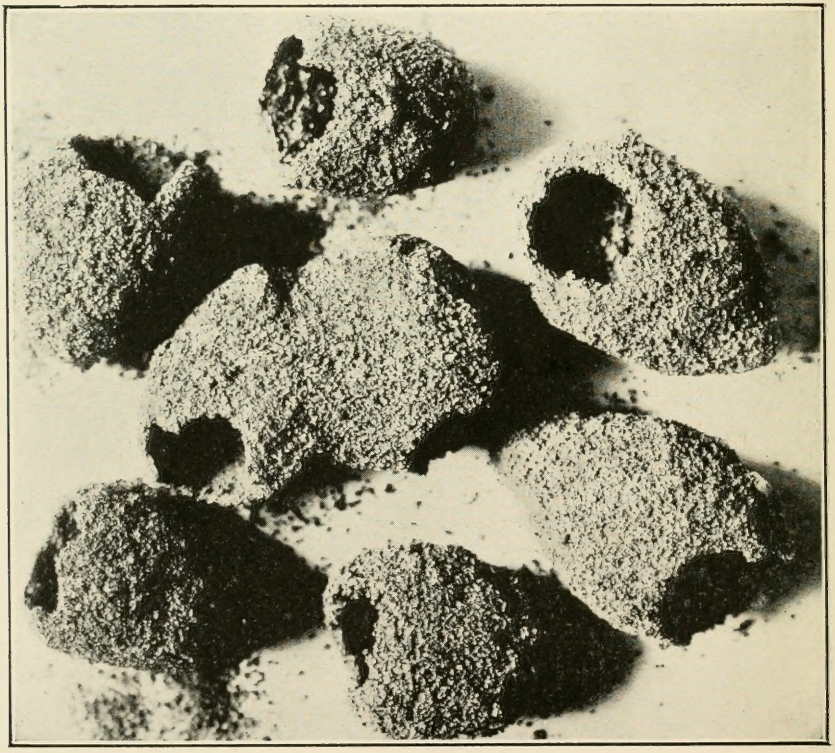
C

GREEN JUNE BEETLE.

A, pupal cell opened to show pupa within; *B*, pupa removed from cell, showing more details of structure. *C*, pupa of a white grub (*Phyllophaga* sp.).



A



B

GREEN JUNE BEETLE.

A, Pupal cells; *B*, same showing exit holes of beetle. About natural size.

green on the dorsal surface, with the margins orange yellow, this latter color frequently extending to other portions of the elytra or wing-covers. The ventral or lower surface is shining green and orange yellow. The thorax is subtriangular and the head is armed with a horn-like process or clypeal horn which is more prominent in the male. The shape and size of this clypeal horn vary. The length of the beetle is from three-fourths of an inch to one inch in the larger individuals.

The average size is much smaller than that of the related species, *Cotinis mutabilis* Gory,[4] and there are other points of difference, the most striking being the uniform metallic green color of the lower surface of the latter and the larger clypeal horn.

THE EGG.

The egg (Pl. I) when first deposited is gray or dull white, oval in outline, and measures about 1.5 millimeters. Within a day or two after deposition the egg becomes perfectly spherical and larger in size, measuring nearly 3 millimeters in diameter. This enlargement of the egg, as has been observed in other related scarabaeid genera, e. g., in Euphoria, is obviously due to the development of the embryo within by the absorption of moisture from the soil.

The egg is perfectly smooth and rebounds or bounces like a rubber ball when struck on a hard surface. Several days after deposition the embryonic outline of the larva begins to take definite shape, as viewed through the thin, transparent eggshell. Finally, when the larva is hatched, what remains of the original eggshell is a mere vestige of thin, transparent tissue.

Mr. J. E. L. Lauderdale, while employed on truck crop insect investigations at Baton Rouge, La., in August, 1916, observed that each egg was inclosed in a small ball of dirt about one-fourth inch in diameter, and that some of these balls, as many as 15 or 20, occurred together. All of the eggs had been placed by the female in the dirt in the bottom of the cage in which they were confined.

THE LARVA.

First Stage.

The larva when first hatched measures 6 to 6.5 mm. in length and 2 mm. in width. The body is cream white and of uniform width; the head is yellowish white, soon turning to light brown, later becoming dark brown at its widest part, measuring 1.18 mm. The dorsal surface of the body is clothed with

[4] A large series of specimens of these two species from many localities show such variation as to lead to the belief that *mutabilis* Gory might be merely a race of *nitida* L., but careful study has convinced the senior writer that they are distinct.

minute stiff hairs in transverse rows, becoming elongated toward the caudal extremity.

Second Stage.

After the first molt the larva measures 15 to 17 mm. (¾ inch) long, and 4 to 5 mm. wide, or nearly three times the size of the newly-hatched larva. The color has changed slightly to light grayish, but apparently there is no other change in general appearance. The head measures across the widest part 2.21 mm.

Third Stage.

After the second molt the larva measures 28 mm. (over a full inch) in length, and 6 to 7 mm. (¼ inch) wide. The hairs on the dorsal surface of the body are more prominent and bristle-like.

The Full-Grown Larva.

The larva, when full grown, measures from 45 to 48 mm. (2 inches) long and 11 to 12 mm. (½ inch) wide. Before transforming to the pupa the head measures 4.14 mm.

Full grown larva.—Length, 40 millimeters, somewhat largest posteriorly, subcylindrical, broader at thorax and eighth and ninth abdominal segments, which are materially swollen. More flattened ventrally, with a distinct swollen lateral ridge just below the stigmata, which rather increases the flattened aspect of the venter. General color, glassy yellowish white, inclining to green or blue toward the extremity. Head, rather small, flattened, well inserted into the prothoracic segment, chestnut brown in color. Dorsal surface of the body strongly transversely corrugate or wrinkled, each of the chief segments having three distinct ridges, the whole body studded with short, thick yellowish bristles, which are most dense on the dorsal ridges and more sparse, but longer, on the ventral and anal segments. Dorsally these stiff hairs are directed posteriorly and materially assist in the dorsal locomotion. The legs are honey yellow, covered with similar stiff bristles without definite tarsal claw. They are short compared with the larvæ of Lachnosterna generally. Prothoracic segment with a honey yellow horny plate in front of the spiracle, which, as usual, is rather larger than the abdominal spiracles. Mandibles short, stout, dark brown, with the left (looking from the dorsum) 4-dentate and the right 3-dentate. Antennæ short, 4-jointed, joints subequal in length, diminishing in width, from 1 to 4, maxillary palpi, 3-jointed, joints subequal in length, terminal narrowest at tip. Labial palpi, 2-jointed, joint 1 longest, somewhat swollen at tip and bearing a short pointed joint 2, on the inner side of its tip. Labium covered with short stout bristles. Maxillæ with long, stiff bristles on the inner surface and with two long, sharp, black teeth near the tip.

The description of the full-grown larva is taken from Riley (20).

THE PUPAL CELL.

When the larva has attained full growth it transforms to the next or pupal stage in a substantial oval cocoon or cell (Pl. III, A; Pl. IV) constructed of earth composed of particles fastened together by a viscid fluid excreted by the larva. At this time the larva loses considerable size by the excretion of the fluid, a habit common to many

forms of beetles. While the outer surface of this cocoon-like cell is rough, the interior is smooth and suggestive of a bird's egg. There is a protuberant area on one side, presumably on the lower surface, which may be due to the excess of fluid voided by the larva while constructing its cell.

This cell measures about $\frac{3}{4}$ inch or 16 mm. in length and $\frac{5}{8}$ inch or 12 mm. in width.

THE PUPA.

The pupa bears some resemblance to the adult or beetle and is white when first formed, changing to light or yellowish brown, afterwards becoming gradually darker, and just before emergence it takes on some of the metallic green and brownish tints of the adult.

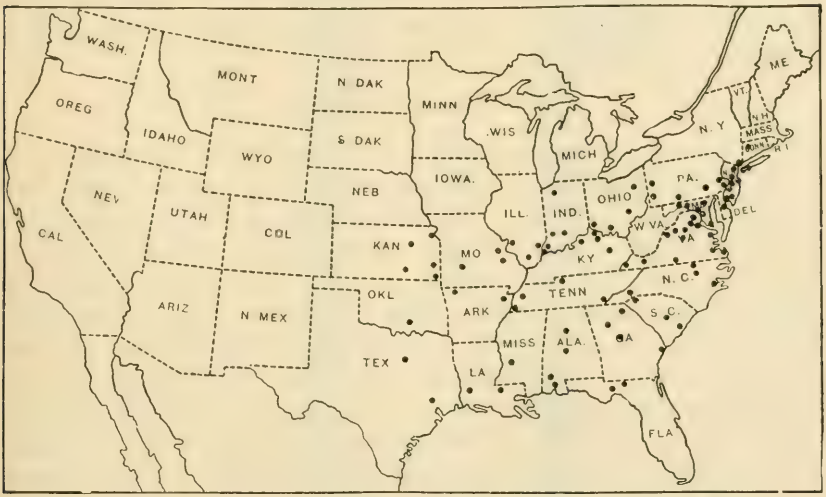


FIG. 4.—Distribution of green June beetle in the United States.

It measures about 1 inch in length and half an inch in width. Other characters are shown in Plate III, B.

DISTRIBUTION AND INJURIOUS OCCURRENCE.

The green June beetle (*Cotinis nitida*) has a wide distribution in the eastern portion of the United States. (Fig. 4.) On the Atlantic coast it ranges from the southern portion of New York State to Florida and Texas in the South, and it is found also in the southern portions of Connecticut, Pennsylvania, Ohio, Indiana, and Illinois. The species continues southward through Missouri, Kentucky, and Oklahoma, and probably the remaining southern States, from which source, however, there are few records available.[5] There is a single

[5] The nearest related species, *C. mutabilis* Gory, occurs abundantly in the arid and semi-arid regions of the Southwest.

record of the identification of the larva from Holyoke, Mass., a locality not shown in the map.

Although the green June beetle has a considerable range, its natural preference for a rich soil, either sandy or loam, renders it important economically in the southern trucking regions. The sandy coast region affords ample opportunity for the increase of this species in trucking regions, and for the same reason it has been able to obtain a foothold in the vegetable-growing sections of Long Island. Indeed, it is evident that the cutting down of forest growth for the settlement and cultivation of the trucking regions of tidewater Virginia and Long Island has been the means of affording the green June beetle ideal conditions for its multiplication. The accumulation of humus following the destruction of the forests and the abundant manuring of these tracts furnish the requisite amount of food for the development of the insect.

NATURE OF INJURY.

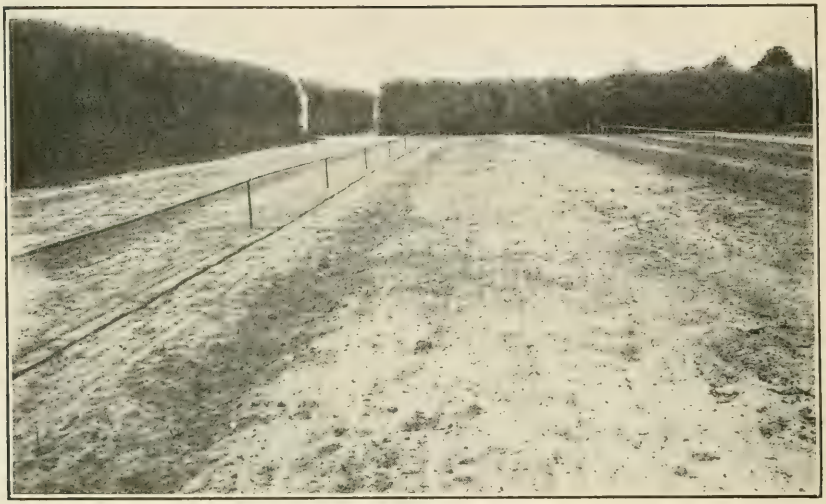
For upward of a half century the green June beetle has been known to entomologists of this country, and its economic status has frequently been discussed. From the literature on this subject it is evident that the majority of our entomologists concede it to be an occasional pest, and that locally, at least, it becomes seriously injurious. None, however, had given this insect very careful study, particularly in regard to the feeding habits of the larva, until the past few years. Since about four-fifths of the life cycle of the insect is passed in the larval form, it is in this stage that the most serious injury is accomplished. Frequent mention is made of this insect as injurious in the parent or adult form, but it has received comparatively little notice as being injurious in the larval state. Recent reports and observations indicate a reversal of conditions, since it has been reported more frequently injurious in the larval or grub stage. Indeed, many such reports are received by the Department of Agriculture every year.

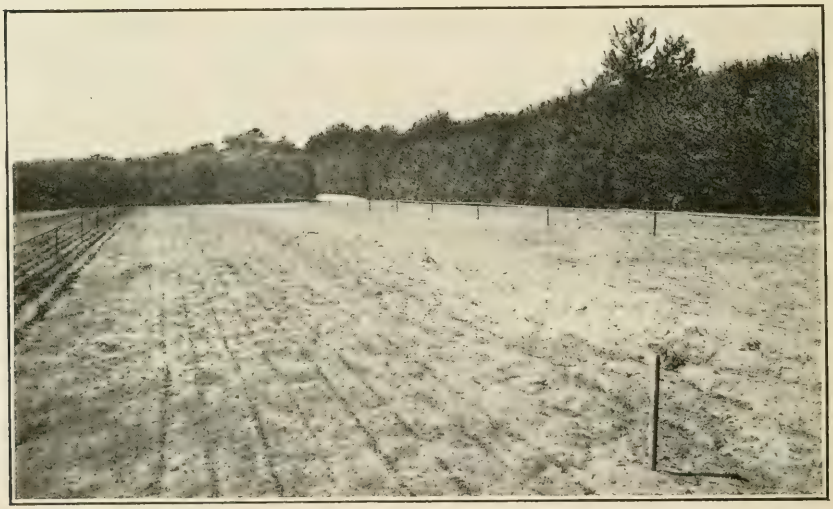
Its habit of breeding in rich loam or rich, more or less sandy soil renders it, at least locally, a serious pest to trucking industries not only of the southern States but also in the East and westward to the Mississippi Valley.

In tidewater Virginia the larva of this insect has done considerable damage intermittently for a number of years. With a view to determining a method for its control in that region a study of its life history and habits was begun there in the fall of 1913.

While the larvæ feed normally and largely on soil rich in humus or organic matter and on manures, rootlets of succulent plants and other vegetable matter on the surface of the ground doubtless formed a part of the insect's natural food before it had acquired the habit of

CUCUMBER PLANTS SHOWING ROOT AND STEM INJURY BY LARVÆ OF GREEN JUNE BEETLE.





VIEWS OF PARSLEY FIELD INJURED BY LARVÆ OF GREEN JUNE BEETLE.

The upper field was re-sown twice, the lower field three times.

WORK OF LARVÆ OF GREEN JUNE BEETLE ON LAWN AT NORFOLK, VA.

injuring vegetable and other crops. The female beetles are strongly attracted to humus, decaying plants, and manure for the deposition of their eggs, but the larvæ or grubs are often directly injurious to plant life by chewing tender seedlings, stems, and rootlets, e. g., as shown in Plate V, which illustrates injury to the root and stem of cucumber. This chewing may be continued until the roots or tender stalks become partially, if not completely, severed. The principal injury, however, is due to the work of the grubs in the soil, where they cause around the growing plants an upheaval, which disturbs the root system mainly by depriving it of necessary moisture. Their constant burrowing and tunneling under the earth in fields and gardens also loosens the surface soil, causing it to dry out and become porous, and retards the growth of shallow-rooted plants in much the same manner. Where larvæ as well as beetles are unusually abundant, a similar effect is produced by the perforations which they make in emerging and again in reentering the soil. (Pl. VI.) Many instances of this nature are known and are here cited.

An extreme form of injury recorded by Riley (20) is to the effect that in the case of injury to celery the heart of the plant became choked with soil thrown up by the larvæ, and the acid excrement of the larvæ induced rot.

Injury to lawns and putting greens is due, in the main, to the little mounds of earth which the grubs leave on the surface of the soil, and on the grass itself. These mounds not only disfigure the lawns and greens but, in the case of the latter, which should be kept smooth, they often deflect the golf ball. Here, also, the burrowing and tunneling, as in the case of attack to cultivated fields, cause the grass to suffer from lack of moisture. Plate VII illustrates how lawns may be disfigured by these mounds, which show plainly on the grass.

INJURY BY THE GRUBS TO LAWNS AND CEREAL AND FORAGE CROPS.

During September, 1902, Mr. E. M. Talcott reported injury by this grub on the golf links of the Washington Golf Club at Rosslyn, Va. The grubs were extremely abundant in that vicinity. They crawled to the surface of the ground at night, and caused injury to the grass by boring short distances just beneath the surface, throwing out small amounts of earth, and making little hummocks of sufficient size to deflect the golf balls and thereby cause considerable annoyance.

October 1, 1903, Mr. F. W. Barclay, Haverford, Pa., sent mature grubs with the statement that they did very considerable damage to the greens and turf of the Merion Golf Club at that place. The grubs were present in large numbers over an area of about 50 acres, and seriously injured the turf, nearly ruining the putting greens. It could not be noticed that the grubs ate the roots of old or growing

grass, but if freshly cut grass were placed in piles, say 1 foot deep on the soil, the grubs would come up and enter into the piles within a few hours. Wasps [6] had learned to search for the grubs in these piles of grass. The specimens sent had been caught after they had entered new grass piles. This suggests that after the insects have been seen to enter the piles they could be killed there by hand methods.

In 1904, Mr. Barclay sent, May 28, a photograph showing the actual damage done to the golf links at Haverford. June 6, Mr. Samuel P. Hinckley, Lawrence, Long Island, N. Y., stated that on his tennis grounds little hills of sand, like ant hills, were thrown up and that by running a hooked wire down into them the white grub could be pulled out.

At Louisville, Ky., special work was conducted by Mr. J. J. Davis on this species. Injuries were observed and reported by him to the golf grounds of the Louisville Country Club. Here the grubs were not directly injurious to the grass, but worked in the putting greens during the night, throwing up little hills of earth. If these were not swept off early in the morning they would be trampled on by the players, thus packing a thin layer of earth over the surrounding grass, killing the grass in these particular spots, and roughening the green, which should be perfectly smooth. At no time were the grubs observed actually feeding on the roots of the grass, and there was no evidence of injury to the grass other than the indirect injury noted. The entire golf course was plowed and seeded in 1909, and the first occurrence of the beetles was in 1911. Each year the ground was heavily fertilized with animal fertilizers, principally sheep manure.

March 6, 1915, Mr. Wm. Buck, Waterloo, Ill., described these larvæ as crawling on their backs and working after sunset and during the night. He stated that they worked underground and that they ate the roots of plants. The grubs worked their way to the surface and collected under pieces of manure, and in their movement upward uprooted and exposed the roots of young alfalfa plants. Their burrowing also made the soil porous and spongy, a condition which accelerates evaporation and has a damaging effect on the plants. Injury was confined entirely to the young plants, those with even a moderately developed root system not being injured. No evidence was found that the grubs actually gnawed the roots.

October 27, 1915, this species was observed in abundance by Mr. A. L. Chapman, Washington, D. C., who stated that grubs of this June beetle had been eating the small terminal roots of grass, chiefly Capitol lawn and crabgrass, practically ruining the entire lawn. Previous attacks had been noticed, but none as severe as this. On three occasions a pint or more of the grubs was taken from the cement floor

[6] "Control by natural agencies," p. 31.

of the areaway leading into the basement. The grubs were most numerous and active on warm, humid nights, especially after rains. The lawn was about 50 by 50 feet, raised about 4 feet from the level of the street, and was kept constantly supplied with water by two hydrants. The grass presented a yellowish brown hue instead of a grass green, showing lack of proper nourishment.

Other instances of injury to lawns and golf links have been reported, but will receive no mention here.

In rearing cages the grubs cut off young stalks of wheat, rye, cotton, sorghum, and paspalum grass (*Paspalum dilatatum*) but did not attack other grasses or corn which were grown in these cages.

INJURY BY THE GRUBS TO VEGETABLE AND GARDEN PLANTS.

Practically all cases of injury mentioned below were accompanied by living specimens of the larvæ of the green June beetle.

February 4, 1901, Mr. S. J. Trepess wrote that the larvæ occurred in large numbers at Glen Cove, Long Island, especially where there was mulching. There were large patches in lawns where the larvæ had entirely killed the grass. He reported that four large beds of geraniums were destroyed, that they ate the epidermis off the plants at the surface of the ground, destroyed strawberry plants set out from pots in September, and attacked roots and crowns, so that every day plants were seen to wilt. Injured plants were replanted about the beginning of October on land where no trace of the insects was visible. Each plant was usually attacked by from two to six larvæ. The soil contained much humus, which our correspondent recognized as the cause of the larvæ being so numerous and thriving. Mr. Trepess had been bothered with these insects in his lettuce and violet frames for two years, and had caught many of them in tomato cans sunk in the ground, the top of the can being about half an inch lower than the surface. February 5, Hon. J. H. Bromwell, Cincinnati, Ohio, sent nearly mature larvæ of this species, with statement that it was acting like a cutworm in working around the stalks of celery and other plants and actually cutting them off close to the ground.

June 11, 1904, Mr. Moritz E. Ruther, Holyoke, Mass., sent specimens about one-third grown, stating that they were feeding on beans, beets, lettuce, potatoes, tomatoes, carrots, dahlias, roses, and other plants, nipping the young plants just underneath the crown, and afterwards pulling the leaves into the earth.[7] The trouble was described as having begun about three years previously and attack was first confined to lettuce and beets; later they were described as attacking

[7] Unfortunately, a common cutworm was involved in this attack, and it is not known positively that the grubs were responsible for the entire injury.

everything grown. Chickens were stated to have refused to eat the grubs.

August 19, 1904, Mr. Henry Chapman, Saltville, Va., sent half-grown larvæ, stating that they were very abundant in celery and strawberry beds. A dozen of varying sizes were found near one strawberry plant that day. The smaller grubs which had hatched from eggs recently deposited by the beetles remained near the surface, while the larger ones occurred farther below. The grubs were not seen to injure the celery until it was put in the ground in the winter, when a good-sized stalk was observed "eaten through." Strawberry plants were destroyed in the midst of a host of these pests. On September 14 specimens in different stages of growth were found 4 to 5 inches below the earth's surface. The beetles were numerous in that vicinity during July. They were observed depositing eggs and soon afterwards larvæ were noted developing rapidly.

October 23, 1907, Mr. Barclay wrote that since 1903, when the Bureau of Entomology had correspondence with him in regard to the occurrence of this insect at Haverford, Pa., it had not appeared at all in 1904, 1905, or 1906. October 26, Mr. P. Haupt, New Athens, Ill., reported that his vegetable and flower garden and a portion of his lawn were very badly infested. Because of the great numbers of the grubs, especially in the vegetable garden, it was feared that great damage might be done the next spring. Lettuce which had been sown several weeks before was undermined so badly when an inch high that the plants died from drought, the grubs having worked around the roots so much that the soil had become as fine and loose as dust. The grubs also ate off the leaves and gnawed the tips of hyacinth bulbs. The presence of the insects in the vegetable garden was attributed to the use of horse manure from the stable.

November 16, 1909, Mr. E. G. Smyth reported the following observations on this species from Churchland, Va.:

> The hard ground between frames of young cabbage is "pepper-boxed" with holes made by these larvæ in entering the ground. The grower believes that they come to the surface during the night to obtain moisture, and reenter the soil before daylight. It is evident that they come forth to feed; but as they can not possibly get into the frames of young cabbage, and as there is very little vegetation outside of the frames, it is a question what they find to eat. Plainly none had gained entrance to the frames, for the soil within had none of their holes at the surface. Once inside, they could play consummate havoc with the tender cabbage seedlings. In the preceding spring, beets had been grown in these cold frames, and something working under the ground, presumably the same larvæ, did considerable damage to the plants. During the intervening summer months the frames were in disuse, so only weeds grew in or between them. Before planting the cabbage in the frames the old soil had been replaced by fresh soil from elsewhere, which accounts for there being no grubs in the frames at this time.

October 8, 1912, James Kenny & Co., Riverside, N. J., wrote relative to this grub as follows:

It is cutting the lawn around here every night, and also cuts the roots of geraniums and other flowers.

January 11, 1913, Mr. E. B. Cantrell, Winston-Salem, N. C., reported that the grubs were very abundant in his garden; so much so as to interfere with the growth of the plants. The two years previous Mr. Cantrell used stable manure freely on his garden and, as he surmised, this was doubtless responsible for the appearance of the grubs in such numbers. Writing March 18, Mr. Cantrell said:

I have observed the grubs for a number of years and have never known them to occur on any kind of land or injure any kind of crops excepting where stable or lot manure had been used. Therefore their greatest numbers are to be found in gardens. The grubs breed and thrive on manure and almost any crops planted there. Especially in dry weather there is damage by them as they plow up and make holes that cause plants to suffer for moisture. Sometimes plants are cut off, tomatoes on the ground eaten, and especially have they injured my celery.

May 17, 1914, Mr. Edward T. Knight, Bureau of Plant Industry, reported injury by this grub to iris, which had been a source of complaint about a year before.

October 24, 1914, Mr. C. F. Turner, Bureau of Entomology, found the grubs doing considerable damage in the gardens belonging to Mr. L. G. Buckner at Memphis, Tenn. Corn, potatoes, turnips, and eggplant were said to be attacked. Mr. Buckner wrote November 5, 1914:

The grubs in our garden keep the ground near the surface pulverized. A rain, of course, packs the ground and in a day or two the ground is again pulverized. We are not sure that the plants died because the roots were eaten or whether it was the continuous working under and around them. They did not bother the plants on top of the ground. We had a very fine patch of turnips and they killed nearly all of them. They also ruined tomato vines and English peas. They attacked fall potatoes, not killing the vines, but I know they ate some of the potatoes; however, not a great deal. Our garden has been well fertilized with stable manure.

During the same month Prof. James Troop, entomologist at Purdue Experiment Station, received specimens from a correspondent at Bedford, Ind., who reported that the larvæ damaged endive. The correspondent wrote October 27, 1914, as follows:

The endive I have covered with a board to bleach. Frequently when I would lift a board off of the endive I would see the worm disappearing in the hole out of which his head had been protruding, and quite often they would in this manner eat a third and often half of the bunch of endives.

The correspondent had adopted two methods for bleaching the endive—laying boards over the plants and bunching and tying up the heads—but the grubs attacked only that under the boards.

December 17, 1914, Mr. A. Patterson, Ensley, Ala., wrote that these "grub worms" keep the soil in the garden very loose, especially around the roots of collards and turnips. They were unevenly distributed in the garden, in 5 or 6 foot areas in holes 4 or 5 inches apart. The surface of parsnips was eaten off in places, some eroded areas extending completely around the root and stopping its growth.

Mr. Thomas H. Jones, Bureau of Entomology, has contributed the following notes, based on specimens:

November 22, 1915, Mr. J. O. Bethes, Franklinton, La., wrote in substance:

This grub was taken from a garden here where the species is doing a great deal of damage. In the daytime the worm penetrates the earth to a depth of about a foot and at night comes to the surface and works up the ground in the manner of a mole. It is doing damage to turnips, cabbage, and other plants growing in the gardens this season of the year.

December 28, 1916, Mr. Jones observed the larvæ in water in a ditch at the Louisiana State University, Baton Rouge, La. Although they were motionless when removed they soon became active when brought into the office. They had evidently bred on the parade grounds on the other side of a walk separating the grounds from the campus, since the beetles had been observed in large numbers in late summer. Numerous trails were found in the wet dirt, and there were holes and piles of freshly worked-over dirt in the grassland. The heavy rains caused the grubs to come to the surface. Prof. O. W. Rosewall had previously seen the grubs above the surface at night after heavy rains.

March 16, 1917, Mr. W. J. Sutcliff, Monroe, La., wrote:

A while back these grubs were in the garden by the millions, and yesterday a number were found dead. They, or some other insect, literally plowed the very top of the ground up, and by doing so they killed the little plants coming up. Digging down below the surface of the ground for three or four inches, the ground is perforated with holes resembling on a small scale those made by crayfish.

October 28, 1918, Mrs. A. M. Kistler, Morganton, N. C., sent specimens of larvæ with the statement that she could furnish them by the bushel, and that they were infesting her garden and hotbed. They were described as destroying everything in the garden—cabbage, turnips, salsify, lettuce, radishes, peppers, tomatoes, and celery. Paris green was tried without effect, and kerosene emulsion was advised.

November 13, 1919, Mr. C. S. Stewart, Baton Rouge, La., reported the grubs of this species in his garden. He wrote:

For the past six years my fall garden has been ruined almost entirely from this cause. It is a grub that grows about 1 inch long, comes to the surface during the night, runs on its back, eats almost everything green, and to give you an idea of their numbers I will say that I have picked up as many as 1,000 in a single night. Where they work and crawl the surface of the ground

looks as if it had been raked. I use stable manure, but within two years have limed the soil. Right now I am plowing out my grub crop, turn the soil, pick up, and throw to the chickens. I haven't anything in my garden this fall except grub worms.

INJURY BY THE GRUBS IN A GREENHOUSE.

A single instance of injury by the grubs of this species in greenhouses was reported in November, 1898. Mr. W. E. Pray, Kinkora, N. J., reported injury in his violet houses (31). The larvæ were first noticed soon after the plants had been put in the bed, and at this time they seemed to do little if any harm, but the ground was described as being "kept well cultivated for 2 inches deep by their movements." As the plants grew, the larvæ, it is stated, began to feed upon the fibrous roots, and were so doing at the time of writing. They were also said to devour the outside petals of the flowers which rested upon the ground and frequently ate into the hearts of the flowers, rendering them unfit for shipment. Specimens of violets showing the reported injury were received with the grubs. A great number of the flowers were described as having been destroyed. It was believed at the time that cutworms might be the real culprits, but no definite conclusions could be reached.

In this connection it should be noted that the grubs are frequently brought into greenhouses with manure, and as a consequence of the superheated indoor atmosphere the beetles issue practically throughout the winter, as has happened at Norfolk, Va., and at Washington, D. C.

INJURY BY THE BEETLES.

Attention has been drawn to the injurious attack of the beetles to fruits. Of these, the thin-skinned fruits, especially figs, peaches, and grapes, are most often damaged, other fruits which have been listed being occasionally or slightly attacked. Injury to figs in South Carolina, Georgia, and other southern States is an annual occurrence, and indeed one of the popular names of this beetle is "fig-eater." From Pennsylvania southward come frequent reports of injury to peaches, often to those which are quite sound, contrary to the opinion of some authors that only decaying, partially decayed, or overripe fruit is attacked. The green June beetle is a very well-known grape pest, and Prof. H. Garman (32) reported injuries to this fruit in Kentucky as follows:

The common green June bug, well known to every Kentucky school boy, becomes very troublesome locally and occasionally by cutting the skins of grapes and utterly destroying the fruit of whole bunches and even whole vines. On the experiment farm at Lexington this pest would, if allowed to work unhindered, destroy the whole crop of the early varieties in the experimental vineyard. It was formerly more troublesome than now, but is liable any season

to appear in such numbers as to be the cause of anxiety on the part of those having the vineyard in charge. The very sweet, thin skinned, early sorts suffer most severely. On a visit to the vineyard, August 1, 1896, I found Moore's Early, Poughkeepsie, and White Imperial being severely damaged, while Brilliant was only moderately injured. The clumsy beetles were clinging to the berries, in some cases a dozen on a bunch, greedily devouring the pulp and leaving them in an unsightly and utterly ruined condition. They were guilty during the same month of injury to early peaches and plums.

Webster and Mally (27) have reported injury by the beetles to tomatoes in southern Ohio, and state that melons are sometimes eaten; corn in the ear is a favorite food, and not infrequently the beetles are sufficiently numerous to injure noticeably both field and sweet corn. They have even been observed injuring young corn plants by gnawing into the stalk, and in one instance young sorghum plants were attacked.

The beetles are also frequently complained of as a nuisance in well-kept lawns and golf greens, because of the little mounds of earth excavated by them as they enter the ground, but they are by no means as troublesome in this respect as are the larvæ.

In 1909 Mr. R. A. Vickery, Bureau of Entomology, observed the beetles at Salisbury, N. C., August 10, feeding on kernels of corn near the tip of the ear, the injury having first been started by the related *Euphoria sepulchralis* Fab. At Wellington, Kans., Messrs. E. O. G. Kelley and T. H. Parks, Bureau of Entomology, observed beetles feeding on young stalks of corn July 19. They were boring large holes near the base of the stalk between the second and third joints. Mr. Kelley repeated this observation and later, August 10, 1911, found them feeding on corn kernels. July 14 of the same year Mr. G. G. Ainslie, Bureau of Entomology, observed the beetles feeding on sweet-corn kernels at Nashville, Tenn.

At the same locality Mr. W. H. Larrimer, Bureau of Entomology, reported injury to sorghum July 21, 1913. The beetles were observed in the "throat" of the plants, evidently having been attracted by the honeydew of the corn leaf-aphis,[8] or by the sweet sap of the sorghum itself. This attack caused the leaves to split at the base, injuring the plants to quite an extent. When the field was revisited a week later the beetles had disappeared, and while the plants were attempting to outgrow the injury, the damaged ones were easily distinguished.

July 9, 1915, adults were observed at Ocean View, Va., flying over lawns and hedges and flower beds, those captured proving to be largely females. Later in the month they were also observed at Portsmouth, Va. The parasitic sarcophagid flies were observed on hedges, and in all probability thus able to deposit their larvæ on the adults of *C. nitida*, resting on the hedges.

[8] *Aphis maidis* Fitch.

June 29, 1916, a single adult was captured at Norfolk, Va. By July 10 numbers were observed flying around hedges and lawns. By August 8 the beetles were observed at Portsmouth, Va., in large numbers. They disappeared about September 20. In 1916 Mr. J. E. L. Lauderdale observed adults at Baton Rouge, La., feeding on the juices of corn. They were observed between July 8 and September 19, none being found after September 22, occurring in greatest numbers in August. On August 4 Mr. F. B. Milliken, Bureau of Entomology, observed the beetles at Wichita, Kans., feeding on eggplant in the early morning, making large ragged cavities in the sides of the main stems or branches.

During the next five years, up to 1922, few complaints of injury were received aside from the normal number to lawns and golf links, these emanating from Maryland, Virginia, District of Columbia, southern Pennsylvania, and New York. Injury to celery and endive, resulting in a loss of more than 40 per cent of the crop which might have been due to this insect, was reported at Sunbury, Pa., but without specimens. Complaints of injury in gardens were received from Louisiana in 1919, one correspondent at Amite stating that for six years his garden had been almost ruined from this cause.

Beetles Entering Beehives.

During July, 1903, the senior author's attention was called to great numbers of dead beetles of *Cotinis nitida*, found under the entrances to beehives on the grounds of the Department of Agriculture, where the living beetles were quite a nuisance. There were considerable numbers of them endeavoring to obtain entrance to the hives, and they occupied the attention of a number of the bees that were as intent on preventing their entrance as the beetles were on getting into the hives. On account of the hard exterior coating of this insect the bees' stings did not appear to penetrate until perhaps after a great many attempts. The beetles were persistent, but very slow and sluggish, and under the circumstances it can readily be imagined that an appreciable amount of honey that might have been produced was lost through the distraction of the attention of the bees to the intruders. The beetles appeared to be utterly unaware of their danger and as stupid as the Scarabaeidae are generally accredited with being, at least when not in flight.

LIFE HISTORY AND HABITS.

In the vicinity of Norfolk, Va., the beetles make their first appearance about the middle of June, reaching their height in numbers by the middle of July and continuing numerous until the middle of August, disappearing about the first week in September.

Throughout a period of from 4 to 6 weeks the beetles occur abundantly, being most active late in the afternoon, when they fly either close to the ground or soar high among the tree tops. When they alight on trees serious injury sometimes results from the beetles gnawing into the young twigs, causing the latter to break off. The beetles are also attracted to ripe fruit and gather by dozens on ripe melons, tomatoes, and green corn.

Mating occurs during periods of rest, when the beetles alight on tree tops, shrubbery, fences, or on lawns and grassy places, the females attracting the males—sometimes many males attending one female. Before oviposition the females, buzzing like bees, fly close to the ground and select a place to enter the soil. After alighting they disappear rapidly from the surface and remain in the ground for two days at a time, sometimes coming to the surface to feed and again disappearing.

EGG LAYING.

The soil condition that attracts the parent beetles for egg laying is land originally sandy, subsequently richly incorporated with humus or organic matter, either in the form of well-rotted manure or decomposing vegetation. Such are the field conditions of the two principal infested localities in the vicinity of Norfolk, Va., where the green June beetle occurs in abundance. This gives a soft, warm, mellow soil, rich in organic food, retaining moisture, yet never soggy or cold during the egg-laying period, and affords easy access for the beetles to enter and deposit eggs. The conditions are ideal for incubation and the subsequent work of the larvæ. Cage experiments demonstrated that a pure sandy soil does not attract the beetles to oviposit, but when well-rotted manure is added in about equal portions the beetles readily deposit their eggs.[9]

The reported finding of larvæ in dung has often raised the question as to whether eggs are deposited in manure. There are instances on record where larvæ have been so found, and the larvæ have received the local name of "dung grubs." Mr. F. Richardson, of Portsmouth, Va., states that about 1908, when he first began hauling cow manure on his farm, he often noticed that hardened or caked pieces of dung when broken revealed the presence of numerous "grub worms," of what he supposed to be this insect. Several years after the use of this manure his place became noticeably infested with the grubs, so that he finally discontinued the use of this manure and supplanted it with stable manure. During the height of their season the beetles were often observed entering and issuing from the soil in the process of

[9] The beetles were induced to lay in pure sand, although reluctantly, and with much effort on the part of the female to escape confinement and to search through the sand for a suitable spot for deposition.

egg-laying. This matter of the dung-feeding habit will be discussed further under the heading "History and literature," p. 28.

Period of Incubation.

The period of incubation in the field, as will readily be understood, depends in a large measure on climatic conditions for that period, and moisture particularly plays a part in the development of the embryonic larva. This fact has been illustrated with eggs kept in the laboratory in vials. It was determined that the eggs when first deposited are small in size, but with suitable moisture conditions finally become larger and assume the spherical shape, the larvæ hatching within a period varying from 12 to 14 days. Eggs kept in vials in which the sand is allowed to become dry remain small and will not develop until suitable conditions of moisture occur. The incubation period is then very much prolonged, and the resulting larvæ are not so vigorous and are somewhat smaller than the average. Usually the normal period is from 10 to 15 days. The depth at which the eggs are deposited in the field provides a temperature nearly uniform, and even during dry weather the moisture content of the soil at a depth of from 6 to 8 inches can be but slightly affected. The length of the incubation period, as observed in eight instances, is given in Table I.

Table I.—*Incubation period of Cotinis nitida.*

No.	Date of deposition of eggs.	Date of hatching of larvæ.	Incubation period (days).
1	Aug. 5	Aug. 17	12
2	Aug. 14	Aug. 23	9
3	Aug. 16	Aug. 30	14
4	Aug. 21	Sept. 3	13
5	Aug. 23	Sept. 6	14
6	...do.....	Sept. 7	15
7	Aug. 25	Sept. 13	19
8	Aug. 30	...do.....	14

Oviposition in Tidewater Virginia.

All the pupal cells obtained in 1916 were placed in a large cage, and adults began to issue in July. Table II shows the date of copulation, the number of masses of eggs deposited by each female thus separated, and the total number of eggs deposited. A pair in copulation was isolated and a record made of egg laying. Flowerpots containing an equal mixture of sand and soil, having an abundance of organic matter, and about 9 inches in depth, were used for study, and were examined frequently, the examination being greatly facilitated by the ease with which the soil was removed entire from the

pots. This simulated natural conditions as nearly as possible. Glass jars containing 6 inches of soil were also used.

When the pots were examined the female was very often surprised during oviposition. On one occasion the burrow leading from the surface to the bottom of the pot was excavated along one side of the pot, so that the actual manner in which the nest was prepared before the eggs were deposited was observed. In this instance the beetle had widened the burrow considerably, forming an egg-shaped cavity with the larger end towards the bottom of the pot. Its head was turned upward, and was evidently used in the formation of the cavity. The pot was replaced in its normal position and several days later, when again examined, revealed the following conditions: When the pot and about half an inch of the soil were removed, several eggs, each separated from the others, were found, as shown in Plate I. These were removed, with a layer of soil, when other eggs were found, the process being continued until the entire mass of 27 eggs was removed.

TABLE II.—*Number of eggs laid by bred adults of Cotinis nitida, Norfolk, Va., 1916.*

Cage No.	Copulation date.	First mass.		Second mass.		Third mass.		Fourth mass.		Total number of eggs deposited.
		Date.	Number.	Date.	Number.	Date.	Number.	Date.	Number.	
a[1]	July 25	July 27	56							56
b	July 31	Aug. 2	20	Aug. 4	16	Aug. 18	14	(2)	33	83
c	...do...	Aug. 4	25	Aug. 14	14	...do...	12	Aug. 28	3	54
d	July 28	...do...	13	...do...	8	...do...	9	Aug. 20	8	38
e[3]	July 31	Aug. 2	12	Aug. 4	38	Aug. 16	27	Aug. 28	16	93
f	July 29	...do...	14	Aug. 14	14	Aug. 18	8			36
g	Aug. 1	Aug. 4	22	...do...	29					51
h	...do...	...do...	27	Aug. 18	20	Aug. 28	27			74
i	Aug. 8	Aug. 14	15					(2)	15	30
j	...do...	Aug. 18	19	Aug. 24	10	Aug. 28	7			36

[1] Female escaped, all eggs found deposited in one mass.
[2] Dissected.
[3] Female taken from pupal cell, copulated soon afterward.

It is evident that the female after preparing the burrow or nest, as already described, deposits several eggs and packs soil around them, continuing the process, layer after layer, until the entire mass is deposited. Since the packing is very thorough the mass of eggs separates from the nest very readily if moist, creating the impression of being deposited in a ball of soil.

The number of eggs deposited at one time or in a mass varies from 12 to 27. In one case 56 eggs were found, but since two sizes were observed at one time it would seem that the female, if not disturbed while in the nest, returns and deposits other masses. When disturbed, as was necessary in cage experiments, four masses of eggs were the highest number deposited by a single beetle, as shown in Table II.

It is evident that a female after depositing a mass of eggs comes to the surface to feed or to rest, later returning to the burrow (in cages, only if the nest is not disturbed) to deposit other eggs, and continuing this until the quota of eggs is deposited. Such are evidently the natural field conditions. In confinement the females were disturbed and new nests had to be constructed each time they desired to oviposit. This probably accounts for the long period of egg laying (nearly a month) as shown in the tables.

LIFE HISTORY OF THE LARVA.

When the embryonic larva is ready to hatch it causes the egg to split transversely at a point where the head and anal end of the larva touch within the egg. Immediately on freeing itself from the eggshell it becomes quite active, crawling on its back as do the older grubs when placed on the surface of the soil. In two instances a recently hatched grub crawled at the rate of 15 inches a minute, and nearly mature individuals travel over 2 feet a minute.

The grubs grow very rapidly, feeding on animal manure and similar decomposing matter, and their presence becomes more conspicuous daily. They are most noticeable in the late fall, and it is at this time that complaints are most frequent.

The first grubs hatch the first of August, and often by the middle of that month they become noticeable in lawns and gardens. At this time numerous young grubs will be noticed in the same areas, as though they worked in colonies, which is to be expected, since a number of eggs are laid close together. Later the larvæ scatter, and infestation of the lawn or garden becomes more or less uniform.

The grubs have distinct open burrows which average 6 to 12 inches in depth, although late in the fall they may reach a depth of a foot and a half, and the surface hole is about the size of one's thumb. The burrows usually go almost straight down, although there may be lateral burrows, and during the day the grub is likely to be found at the bottom. At night dirt is thrown out at the exit of their burrows, the little mounds of earth thus appearing being from 2 to 3 inches in diameter and closely resembling ant hills, the particles of earth being somewhat coarser, but not as coarse or pasty as is earth excavated by angleworms or nematodes.

Toward winter the grub usually deepens its burrows, and during the colder months remains inactive at the bottom; but it is quickly revived even during short periods of warm weather, and not infrequently continues its work on warm days. In fact, even as far north as Louisville, Ky., the grubs are active during parts of the months of January and February.

As warmer weather returns in the spring the grubs likewise make their normal reappearance, and after a short period of feeding be-

come full grown, prepare their pupal cells a few inches to 8 inches below the surface, and pupate within these. Pupation takes place the latter part of May or first of June.[10]

During cold spells in late fall and during winter, the larvæ penetrate deeper into the soil. In tidewater Virginia certain crops are grown during winter under frames, and in such cases, when weather conditions are mild, the larvæ may continue active during the entire winter. In the field, the larvæ are active during warm spells in winter, otherwise they remain inactive in the ground at a depth of from 7 to 10 inches. Early in spring activity is much increased, and as the larvæ are approaching full growth at this time they often prove injurious to plants sown at this time, and to others that are set out. The larvæ continue active until the beginning of June, their activity ceasing gradually as the time for transforming to pupæ approaches. By the middle of June the majority have transformed.

The newly-hatched larvæ can live several days without feeding, as long as the soil is moist.[11]

Observations on the feeding habits of the larva of the green June beetle in the field in tidewater Virginia were made frequently from the time the larvæ were first hatched until they were ready to pupate, and these, together with the experience of experts and farmers who have had practical experience with this white grub, will serve as a criterion in judging the injurious status of the larva to crops.

From the time the larvæ hatch until some time after the first molt, they invariably work in the vicinity of where the eggs were deposited. Later they come nearer the surface of the ground. In the trapping experiments conducted for control, only larvæ that had molted at least once were captured, indicating that before that stage is reached they do not usually come to the surface. After the first molt, the larvæ are about three-fourths of an inch in length when extended. They become exceedingly active and their abundant numbers in the soil are plainly visible by the numerous perforations and ridges produced around the plants.

Probably the most important factor in judging the injuriousness of the larvæ is their extreme activity in the soil. This activity is in large measure responsible for the damage they do to crops. Where larvæ are abundant seedling plants are thrown up from the soil or buried beneath. In several instances two to three replantings have been found necessary before a fair stand of plants could be obtained

[10] The notes in some of the foregoing paragraphs are also recorded by Davis and Luginbill (45).

[11] In vials of moist sand containing no food whatever larvæ were kept alive for three or four days after hatching without any apparent effect on their health. The data in regard to the molts of the larva were determined by confining larvæ in vials and supplying them with fresh food daily by changing the soil. The soil was prepared by mixing sand and compost in equal proportions. Under these circumstances the larva was reared from the time it was hatched until it changed to pupa. The number of molts was thus determined.

(see Pls. V and VI). Many fibrous roots are broken either by the movement of the larvæ traveling from one place to another below the surface or by their feeding when desirable food is near the roots. Certain methods of farming or trucking, particularly those deemed necessary in growing such crops as parsley, lettuce, celery, beets, and turnips, where the seed is sown in drills, afford ample opportunity for the young seedling plants to be injured as stated. Later, in such crops as parsley, for instance, where the plants are grown in close rows, the roots act as a barrier to the movement of the larvæ; hence they are much injured, and the outer leaves of the plants turn yellow, giving additional indication that root injury has taken place. Furthermore, the habit of the larvæ of coming to the surface at night, or of working close to the surface of the soil during cloudy days, is responsible for the undermining and uprooting of many larger plants. The carriage of soil into the heart of the susceptible crops mentioned also causes the plants to become choked, and is likely to produce rot. In many instances rows of plants have been found thus injured, lettuce being the greatest sufferer in this respect.

The object of the larvæ in coming to the surface at night probably is to change their feeding areas. Hundreds of larvæ may be observed traveling promiscuously, and the fact that the light of a lantern causes them to become stationary, or immediately to bury themselves beneath the surface, has prevented the determination as to whether or not they feed on the surface.

Where the larvæ occur abundantly the continual stirring up of the soil renders it unfit for the growth of crops of any kind. Innumerable tracks are made by the larvæ while crawling on their backs, and as they crawl over plants leaves are buried, or soil carried into the hearts of growing plants.

Number of Molts.

During the growing period the larva molts twice, a third molt occurring when the larva transforms to pupa.

A large series of larvæ were successfully carried through the molting stages in tidewater Virginia, and it was determined that the vigor of the larva when hatched, the richness of the food during its active existence, and the frequent changing of the soil all played an important rôle in determining the period before the larva molts. In other words, when all conditions are favorable for rapid growth, including warmth and the necessary moisture, the time between molts is comparatively short. From the time the larva is hatched until the first molt the minimum period observed was 13 days and the maximum was 27. From 38 larvæ carried through the molting stages the average number of days before the first molt occurs was determined to be 18. The minimum and maximum number of days

before the second molt occurred were 15 and 32, respectively, while the average number of days between the first and second molts was 26.

Thus a larva hatched July 27 will molt the first time in 13 to 15 days, or about August 11. The second molt will take place in about 20 to 25 days, or approximately the first week in September; from the latter date until late in the following spring, a period of nearly 9 months, the larva grows, hibernates, and matures before it finally transforms to pupa.

PUPATION.

When about to transform to pupa the larva constructs a cell by cementing particles of soil together. Several days after the cell is constructed the last larval skin is cast, disclosing the pupa. On opening the pupal cell the third or last molt of the larva may be

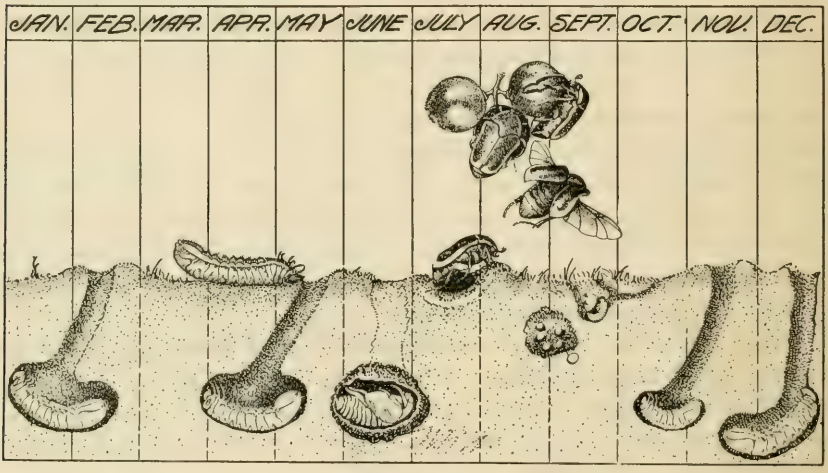


FIG. 5.—Diagrammatic picture showing life history of green June beetle. (Walton del.)

seen. The time required to change from larva to pupa in the cell varies from 3 to 8 days, according to temperature. The pupal period consumes three weeks or more, also depending on temperature.

Cocoons from which the adults have escaped are shown in Plate IV, B.

SUMMARY OF THE LIFE CYCLE.

The life history (fig. 5) of the green June beetle occupies only one year. Approximately four-fifths of this time is spent in the larval form. The most active growing larval period occurs in the first 2 months of its life, although 7 additional months are required in completing full growth.

In tidewater Virginia the beetles appear about the middle of June, continue through the months of July and August, and disappear by the first week of September. Eggs are deposited from the middle

of July and through the month of August in the soil at a depth of 6 to 8 inches. The eggs hatch in from 10 to 15 days, and the larvæ pass their lives in the soil, feeding and molting twice by autumn. By late fall the larvæ have become three-fourths grown—in some instances nearly full grown—and pass the winter in the larval form, either inactive or active, depending on temperature conditions. Early in the spring the larvæ resume feeding until the latter part of May and the first week in June, when they finally form cells in which they transform to pupæ. The pupal or dormant stage lasts about three weeks, and the adults begin issuing from about the middle of June onward.

LARVAL FOOD HABITS.

Experiments to determine if larvæ feed on the roots of plants must necessarily be taken for what they are worth, for the reason that confining the larvæ in a given area, as in flowerpots or boxes, places them under conditions subject to the will of the experimenter, and the larvæ invariably will net results subject to the conditions imposed on them. These results, therefore, may be misleading.

In confinement wheat plants were grown to provide food for the larvæ, and Riley (20) states that the larvæ feed on the roots of the plants. The following experiments for the purpose of determining this factor were conducted by the authors. An equal number of larvæ were confined in 8-inch flowerpots under the following conditions:

Experiment No. 1.—In a flowerpot containing pure sand the larvæ were very restless and worked the sand over thoroughly, evidently looking for food, or a means of escape. Some of the larvæ succeeded in moving the broken pieces of stone at the bottom of the pot and escaped in that way.

Experiment No. 2.—In a flowerpot containing pure sand, with a growing cucumber plant, the larvæ fed on the soil surrounding the plant roots and on the roots of the plant, even gnawing the stem 1 or 2 inches above the ground.

Experiment No. 3.—In a pot containing garden soil they fed on the organic matter.

Experiment No. 4.—About 25 larvæ were placed in a large battery jar with moistened earth, October 12. On the 17th, believing that the larvæ might be more hungry than when received, some beet roots were placed in the jar with the leaves remaining. These leaves touched the surface of the earth, and when they were examined two days later it was found that the stems had been cut in most cases, and that the leaf and stem together had been drawn down into the cells of the larvæ 5 or 6 inches below the surface.

Experiment No. 5.—A small lot of larvæ was separated from the main lot and placed in another jar with a large tuft of grass, roots, and all the grass blades, and treated in the same manner, but the roots were not materially affected. This experiment suggests that there can be no doubt whatever that larvæ feed, to a certain extent at least, on vegetation, and that this is done when they come to the surface of the earth, which they so frequently do at night, particularly after rainy spells. It also suggests that ordinary poisoned baits of grass or other vegetation strewed about the lawns and golf links where these insects are so injurious would be a more or less effective remedy, as the insects feed enough so that if the vegetation were well poisoned and strewed in such manner that it would attract the larvæ for protection as well as food beneath, they would eat enough to be killed.

Experiment No. 6.—Still another experiment was made with about half as many larvæ, which had been kept without food for several days. A beet root and a small cabbage plant were placed in a jar so that the leaves all projected. The beet was not touched the first night, but five small cabbage leaves were dragged under the surface. In each case the leaves were left and the stems were attacked first. In the case of the fifth leaf the stem had been about half eaten and dragged under.

Experiment No. 7.—In a pot containing garden soil and a growing cucumber plant most of the larvæ were found feeding on the soil. One larva, however, was observed feeding amongst the roots of the plant, many fibrous roots were broken, and others had been injured by the larvæ feeding upon them.

HABITS OF THE ADULT.

The beetles make their first appearance above ground during June in the middle Atlantic region and not until July in the more northern range of the species, the exact time being dependent on atmospheric conditions, especially temperature. They gradually become more abundant until August, after which time their numbers usually diminish or at least become less noticeable.

During their periods of abundance the beetles, according to Davis and Luginbill (45),[12] appear about daybreak, the females appearing first, at least relatively more frequently than the males, from daybreak until after sunrise. Shortly thereafter the females begin to settle to the earth, often first searching for the exit of a burrow or starting a fresh hole and then resting in the grass preparatory to mating. By this time the males predominate, becoming relatively

[12] Observations were made at Louisville, Ky., except as noted and are substantially as already published.

more abundant as the morning advances, and the number of females gradually diminishes. By 7 a. m. (later on cloudy days) the males are exceedingly numerous, buzzing here and there in search of females. In heavily infested localities the air near the ground becomes "alive" with the beetles, which fly rapidly back and forth, buzzing incessantly, giving the impression of a clover field humming with bumblebees. They usually fly 6 to 12 or 18 inches above the ground, but often higher.

From observation it appears quite certain that the male is attracted to the female by the rather strong and sickening odor of a milky fluid secreted by the latter, for he usually drops to the ground within a few inches of a female and, searching through the grass, seems to have no difficulty in finding her within a minute or two. Male beetles will alight near a female even when the latter is completely hidden from view. In one case a male was seen attempting to mate with a dead female, and as she was lying on her back it is hardly probable that form or color was the attractive force. Often one finds a "nest" of beetles in the grass, there being a number of males and only one female, more often a male and female in copula and the other males vainly endeavoring to copulate with her. In such a "nest" as many as eight males have been observed attempting to mate with one female. From these facts, and since the female invariably secretes this odoriferous fluid, it is believed that the females are detected through the sense of smell.

Mating lasts only a few minutes, for, as a rule, after this space of time the female forcibly frees herself from the male by entering her burrow or crawling under matted grass. In one instance a pair was found in copula about 5 inches below the surface in the soil of a breeding cage, and even after their removal from the cage they did not separate for some time.

From 8.30 to 11 a. m. the number of beetles gradually diminishes and after that comparatively few are seen in flight. By 1 p. m. and throughout the afternoon only an occasional beetle is observed flying about. On one of the days when observations were made it rained most of the morning until 10.45, after which the sun came out and the beetles appeared in numbers. At Columbia, S. C., the beetles were most active between 11 a. m. and 3 p. m., being quite difficult to capture at this time, since even when feeding they took flight at the least disturbance. Evidently most of the beetles spend the night in the soil or under débris of one kind or another, but males were occasionally found at night resting in shrubbery, quite inactive and not feeding, nor were they attracted to the electric light carried by the observer.

On entering the ground the beetle throws up a little mound of earth not unlike that made by the grub (see p. 21). The mound resembles

a small ant hill, but differs in that the particles of earth are coarser. (Pl. VII.) More often the males, after their daily flight or after mating, burrow just beneath grass or loose sod, and in the case of the putting greens of a golf course which are kept perfectly level and the grass closely clipped, small mounds, resembling miniature mole burrows, indicate the presence of a resting beetle beneath. The females after mating go deeper into the soil, that is, from 2 to 4 or 5 inches, where they lay the eggs for the next generation.

The beetles evidently detect their food by the sense of smell. An overripe fig was placed in a rearing cage with a number of beetles which had not fed for several days. Immediately one about 6 inches distant moved its head as though scenting the odor, circled the fruit, and soon thereafter moved directly toward it and began feeding on it. In another cage beetles refused ripe figs which were not bruised, but when the skin was removed immediately attacked them. While this does not definitely prove that the beetles will not attack perfectly ripe fruit it tends to show that they are not attracted to fig trees except by the odor of bruised fruits and it is of course possible that they may when abundant attack fruits both perfect and injured.

HISTORY AND LITERATURE.

While the literature of the green June beetle is large and there are many unpublished notes in the Bureau of Entomology, it will not be necessary in this article to mention any but the more interesting facts, which have a bearing upon the destructiveness and the plant-feeding habits of the species.

In the original description of the species, published in 1758 by Linnaeus (1, p. 350), the name *Scarabaeus nitidus* was used. "*Habitat in India*" was obviously erroneous. The genus Allorhina or Cotinis is neither European nor Asiatic, and there is no doubt that *C. nitida* is a native American species. The second habitat, "Carolina," mentioned by Linnaeus (2, p. 26), refers to either North or South Carolina.

The first account of the habits of this species was published in 1865 by Dr. B. D. Walsh (3). Early records of the Bureau of Entomology show that the larva was probably first reported to attack useful plants in 1868, by G. G. Baker, who observed it in strawberry beds at South Pass, Ill. The larvæ were confined with wheat roots, of which they devoured great quantities. April 15, 1868, they were found in cocoons; by May 14 the change to pupa had taken place; and by June 2 the adults had issued.

Mention of the green June beetle was made by M. D. Thompson (4) of Illinois in 1869. He stated briefly that the grubs feed on the

roots of plants and sometimes become quite injurious to the strawberry. It is rather strange that this species should have first attracted attention in Illinois in the most northern boundary of its present habitat, when we take into account that it is normally a habitant of the South. It was reported again from Illinois in 1874 by William LeBaron (5, p. 89–90).

In 1879 Dr. L. O. Howard (6, 7) noted September 15 that the larvæ were found crawling on their backs in immense numbers on the grounds around the Capitol at Washington, D. C., and that after heavy rains at that season they were sometimes so numerous that bushels had been swept away together. They were also found crawling about the pavements of the Department of Agriculture. September 5, 1881, Mr. B. P. Mann brought in grown larvæ which had been found around the roots of a pear tree.

In 1883 William Saunders (8) gave a brief account of this species with an original figure.

The first general account of this insect was given by Forbes in 1884 (9, p. 149–150). In this article Howard's previous paper is quoted and characters are given for the separation of the beetle and its larva from those of Lachnosterna (Phyllophaga). A similar article was published by the same author in 1884 (10, p. 245). In 1884 also C. W. Leng (11) recorded an abundance of this species in the Carolinas and Georgia, including notice of injury by the beetle to walnut trees.

In 1885 Dr. J. A. Lintner gave a general account (12) of the feeding habits of both larval and adult stages

In 1887 Dr. W. H. Ashmead (13, p. 16) mentioned the feeding of the adult on corn in the ear.

In 1888 W. B. Alwood (14) reported the successful use of kerosene emulsion against the grubs on the Capitol grounds at Washington, D. C. The same year Messrs. Riley and Howard (15) mentioned the feeding of the adult on the fungus *Roestilia aurantiaca*, and the following year (17) reported an abundance of beetles and their injury to peaches in the District of Columbia.

Reports from Kentucky in 1890 (18) by Prof. H. Garman and C. W. Mathews indicate that the grubs were injurious to strawberry and the beetles to fruits, particularly grapes. In 1891 W. B. Alwood (19, p. 26) stated that he had bred a dipterous parasite from the adult. In 1895 Garman (23) further reported that the grub "feeds on living roots of grasses, strawberries, and other plants, and never, as far as I can learn, eats dead vegetable matter." The beetles were also observed feeding in the husks of corn when the grain is in the dough stage, boring in the latter often well down to the base of the ears, and they sometimes proved annoying to the honeybee by persistently trying to enter beehives.

The importance of the species as a truck-crop pest was further noted by Riley in 1893 (20), when he stated that an acre of celery at Rives, Md., was found fairly teeming with the grubs. No direct injury was noted to the roots, but the heart of the celery became choked with soil, and rot was induced by the acid excrement of the larvæ. The great abundance of the larvæ on this area was attributed to heavy mulching with rotten straw, the odor of which obviously had attracted the parent beetle to deposit her eggs. The same year Dr. J. B. Smith (25, p. 510–511; 26) stated that the larvæ in 1896 were more abundant than those of May beetles, and that their work beneath the sod is sometimes so rapid and complete that the whole can be rolled up like a rug, every fiber of the roots having been destroyed. Forbes (22, p. 280–281) stated that this grub is normally a grass insect, but also infests strawberry fields.

From Ruxton, Md., it was reported that in 1897 hundreds of California privet plants were destroyed by the grubs.

The conviction of the authors engaged in truck-crop insect investigations, that the larva is more injurious than the beetle, is not shared by all entomologists. M. V. Slingerland (24) wrote that the grubs during growth are harmless, feeding largely on vegetable humus, but when they attain growth, they often injure roots of strawberry plants and grasses.

In 1898 Dr. Howard (28) wrote a somewhat extensive article on the green June beetle in which the statement was made that the actual amount of damage done by the larva was problematical, and in fact that it was doubtful whether the larvæ normally do damage at all. In spite of this, numerous records of injury had been made long before this date, some of which Dr. Howard noted, and a considerable number of reports have been received since, particularly during recent years, when many complaints have been made of injury by white grubs, which proved on receipt of specimens to be *Cotinis nitida*.

In 1900 the senior author (29, p. 55), in an account of insects and the weather, stated that this species was less abundant in the District of Columbia than usual. The same year J. B. Smith (30, p. 282) gave notes on the habits and occurrences of the species in New Jersey. The following year the senior author (31, p. 76–77) reported injury by the grubs to greenhouse plants, but the injury might have been partly due to cutworms.

In 1905 Dr. Forbes (35, p. 101–103) published a general account which included notes on the characters of this and other so-called species of "June beetles."

In 1909 Prof. H. Garman (35), in writing of this species, stated that it was destructive to corn planted near manure heaps and mentioned injury by the beetles gnawing the tips of ears of corn.

In 1910 Prof. W. S. Blatchley (37, p. 995–996), after furnishing a technical description of the species, gave some brief notes on its habits, including some references. The same year J. B. Smith (38, p. 321, fig. 129) published notes on the occurrence of this species in New Jersey, and in 1910 (39, p. 444) reported injury to lawns by the larvæ in southern New Jersey, recommending kerosene emulsion.

In 1914 Prof. E. N. Cory (40, p. 13–15) stated that the adult did serious damage to corn by cutting holes in the leaves. He recommended a rigid cleaning up in the fall and fall plowing. The same year Prof. Franklin Sherman, jr. (41) published a summarized account of this and other species of grubs. The same year also Slingerland and Crosby (42, p. 296–298) gave a concise account of this insect as a pest on peach and other fruits.

In 1921 Mr. J. J. Davis and Mr. Philip Luginbill, Bureau of Entomology (45), furnished the most complete account of this species that has heretofore been published. It includes many instances of injury, especially to lawns and golf greens, and a most excellent account of the life history and habits, together with technical descriptions of the different stages. It also contains a consideration of natural enemies and methods of control, especially with regard to the occurrence of the insect in lawns and golf greens, and a bibliography of economic literature.

CONTROL BY NATURAL AGENCIES.

White grubs in general have many natural enemies without which there is no doubt that injuries from this source would be much greater. The grub of the green June beetle is without doubt largely held in control by natural enemies.

INSECT ENEMIES.

Blow-fly Parasites.

In the vicinity of Norfolk, Va., two species of parasites were reared from the pupa and adult of *Cotinis nitida*, one of which proved to be new.

Sarcophaga utilis Ald. was reared from the adult, and as many as two and three parasites were obtained from a single parasitized individual. This parasite is a comparatively large-sized species and sometimes occurs quite abundantly along the seashore. Hundreds of these flies were observed frequently on seaweeds along the coast, sometimes alighting on any marine animal matter cast up by the sea. From the number of the parasites observed it would appear that this species is a natural inhabitant of this locality, and might prove parasitic on other insects besides *Cotinis nitida*. The habits of this fly are not definitely known in regard to its method of ovipo-

sition on the host. Several beetles were observed with larvæ attached to their bodies near the base of the head and thorax, and it may be that the parasite normally deposits its larvæ on that part of the host. The reason for this belief is that parasitized beetles which have been examined usually have their heads severed at the junction of the thorax. A large number of beetles thus examined also have the contents of the thorax and abdomen devoured by the parasitic larvæ. When the parasitic larvæ become mature they leave the body of the host and transform to pupæ either at or a little below the surface of the soil.

Sarcophaga (*Helicobia*) *helicis* Towns. was reared both from the pupa and adult. It is only about half the size of the former, but is more commonly parasitic on *Cotinis nitida*, and is known as a parasite on a number of other insects. It is quite common in many localities and is widely distributed. The rearing of this species from the pupa of Cotinis leads to the question as to how the adult parasite oviposits (33, p. 25). Evidently the larvæ must be parasitized, and in order to reach the host the only plausible method is for the parasite to enter the ground and deposit the larvæ on the host larvæ. Considering the habit of this white grub in making perforations to the surface of the ground, it would be an easy matter for the fly to enter a burrow leading to the abode of the host and parasitize it.

The ability of the host larva to live for a considerable period after being parasitized, and even to pupate in many instances when pupal cells were found with the parasitic larva, is somewhat remarkable.

An instance of this is recorded by Mr. H. A. Morgan, Bureau of Entomology, when *Sarcophaga* (*Helicobia*) *helicis* Towns. was reared from grasshoppers, and it was found that the functions of the grasshopper, including mating and ovipositing, continued normally for a period of 95 days, notwithstanding the fact that it harbored the parasite for that length of time.

Pupal cells contained as many as six or more parasitic larvæ of *Sarcophaga helicis*, and the contents of the cell were completely devoured. In some instances the last larval skin of the host larva was found in the cell, indicating that the larva was able to transform into pupa before succumbing to the attacks of the parasitic larvæ.

In laboratory observations the parasitic larvæ after becoming full-grown transform to pupæ on the surface of the ground or become attached to the body of the beetles when they emerge from that source, or may even enter below the surface of the ground for some distance.

The good service which this latter parasite may render is, however, problematical. Reasoning from Morgan's observations on grass-

hoppers, the function of mating and egg laying by the beetles might continue normally in spite of their being parasitized.

A Digger-wasp Enemy.

Among the known natural enemies of the green June beetle, if we except such birds as robins and blackbirds, is one that is more than probably responsible for the extreme fluctuations in the numbers of this species observed in some years and in certain localities.

During the months of August and September of the last decade of the nineteenth century, on numerous occasions the flight of a digger wasp, *Discolia dubia* Say (fig. 6), was observed by the senior author. The wasps gradually increased in numbers until they became sufficiently abundant to attract general attention. The same abundance

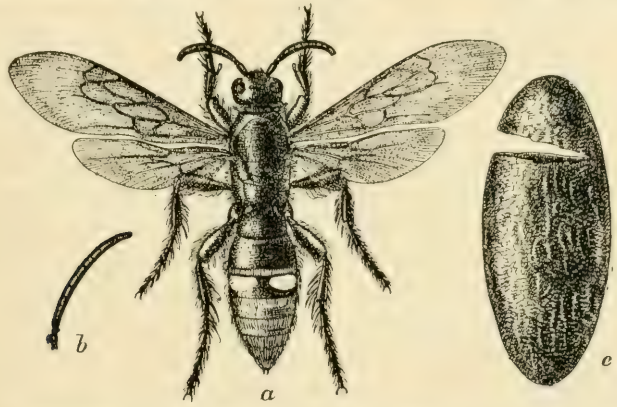


Fig. 6.—The digger wasp (*Discolia dubia*) : *a*, Female wasp; *b*, antenna of male; *c*, cocoon showing opening above. Twice natural size.

was reported in other quarters in the city of Washington, and it was presumed that white grubs of some sort were the attraction. Finally it was learned that the insect seemed to be present only in the male sex. Later the species was reared from *Cotinis nitida* in different localities and reported to the Bureau of Entomology.

In Maryland, near Washington, the same phenomenon was witnessed, and it was also noted that the wasps congregated in great numbers on convenient shrubbery. It may be said in general that the wasp is most conspicuous on lawns and near shrubbery in just such localities as are frequented by its host. One year this species was so abundant in some of the smaller parks of Washington and so disturbed the children who used the parks for playgrounds that the wasp became the subject of newspaper notice.

A few words in regard to the digger wasp above mentioned may be interesting. It is one of our medium-sized species, measuring

about three-fourths of an inch from head to tip and with a wing expanse of about an inch and a fourth. It is subject to considerable variation, however, in size. The main color is black; the wings are dusky with a purplish luster; the first two segments of the abdomen are similar, but the remaining abdominal segments are reddish brown, the third segment being marked above with two conspicuous transverse yellow spots. The female has comparatively short antennæ, and those of the male are nearly twice as long.

In large collections which have been made and in observations the male greatly predominates, females being decidedly rare. The males are also more slender and smaller than the other sex and are provided with strong clasping organs, which perhaps have the power of puncturing the skin. The female is undoubtedly a poisonous stinging form. The cocoon of this species is shown in figure 6, C.

Our first report of this natural enemy of *Cotinis nitida* was received from Mr. F. W. Barclay, Haverford, Pa., who wrote October 12, 1903, and sent numerous specimens of nearly grown larvæ as well as cocoons, showing dead beetles, and cocoons of this digger wasp. He stated that the grubs at that time were becoming scarce. He had observed two of these wasps enter holes made by the grubs and remain there for a few minutes. It was the general opinion of the men working on the grounds of the golf links at Haverford, where the grubs were most injurious, that the wasps sting and kill the grubs. If the grubs were dug up after the wasp had entered the holes, the wasp would be found attached to them. He also stated that the wasp killed the grubs, attacking them on the golf greens in the morning.

We also have record of this species occurring as a parasite of the green June beetle at Harrisburg, Pa., made by the late H. O. Marsh, Bureau of Entomology, about the middle of August, 1906. Numerous individuals were observed flying over soil known to be infested by the host larva and the wasps were observed to crawl into the burrows made by the host.

June 6, 1908, Mr. W. A. Kapner, Charlottesville, Va., wrote that he had seen a wasp of this species collected September 21, 1907, carrying a larva of the beetle when taken. Swarms of the wasps were flying in the autumn of 1907. In a later letter, June 12, our correspondent stated that the wasp was seen dragging the host larva. No doubt the females of this species are quite capable of doing this work, although it would seem to be unusual for the group to have this habit. It is remarkable in any case, since the wasp is so light as to be seemingly incapable of flying with so large an object as this grub, unless the latter is of small growth, more particularly because the grub is usually full of humus and moisture, making it quite heavy for its bulk.

There is no doubt that the female wasp often crawls into the burrows and deposits her eggs on the larvæ, while on other occasions she may drag and fly about with small larvæ until she finds a hole or makes one herself. It has been stated by certain entomologists that wasps of the family Scoliidae are not known to have the power of building nests or of transporting their prey to them for their carnivorous larvæ, in this respect differing from many other solitary wasps such as the cicada killer (*Megastizus* [*Sphecius*] *speciosus* Dru.), whose habits are well known. On the other hand, J. B. Smith has written that they burrow into the ground in search of white grubs, in which they lay their eggs and on which their larvæ develop. That this habit is true of *D. dubia* was proved by additional observations conducted in 1916 at Hampton and Diamond Springs, Va., where the wasp was observed entering openings of the burrows. Many dead larvæ were in evidence at the openings, indicating that the wasp larvæ had fed on them.

It is worthy of note that the presence of the grubs of this species might have escaped notice on the grounds of the Department of Agriculture were it not for the unusual appearance of the wasp parasites *Discolia dubia*, which were noticed first in 1897 and for many years thereafter. During a period of 15 years there was no evidence of attack by the larvæ of the June beetle in Iowa Circle, a little more than a mile north of the affected patch in the department grounds.[13] Both are heavily manured each spring and the Iowa Circle grass is kept moist by constant use of a hose during the warm season. This may account for the discovery made September 10, 1916, that the ground was almost honeycombed with the holes made by the grubs on the latter grounds, a fact which would have entirely escaped notice had not the wasp *Discolia dubia* drawn attention by disappearing entirely in the earth. Upon examination numerous holes were found wherever there were heaps of earth, and these were at intervals of no more than an inch.

MISCELLANEOUS.

There are no doubt many other predacious insect enemies of the white grub under consideration but they have not been reported.

Two individuals of *Scarites subterraneus* Fab. were observed in the District of Columbia, May 17, 1914, associated with larvæ of *Cotinis nitida*, which was said to be injurious to iris.

In the control experiments at Norfolk, Va., where flowerpots and troughs were used, a carabid or ground-beetle, *Cychrus elevatus* Fab., a nocturnal sandy-looking spider, and the northern mole-cricket

[13] A parallel case may be cited for the yellow-necked flea-beetle (*Disonycha mellicollis* Say), which was found one year in great abundance at Iowa Circle, in Washington, D. C., and very rarely in the department grounds on the same food plant.

(*Gryllotalpa borealis* Burm.) were observed, but it is questionable if any of these actually feed on the larvæ.

Macrocheles marginatus Herm., a mite, according to Harry B. Weiss, has been found attached to the adults of this species.

A FUNGUS PARASITE.

Adults of this grub are often found dead and their bodies covered with a fungous growth. In some instances, when a pupal cell was opened, the pupa would be found dead, apparently from the effect of some fungous disease.

In rearing cages maintained by the cereal and forage crop insect investigations the grubs were noted to be attacked by the green muscardine fungus (*Metarrhizium anisopliae*).

The same fungous disease was observed attacking the larvæ at Norfolk, Va., during July, 1916.[14]

From what has been stated in regard to the control of this species by natural enemies, the evidence is that this manner of reducing the numbers of both beetles and grubs, especially the latter, is of the highest importance. In the District of Columbia, and probably in many other localities in similar latitudes, including portions of eastern Pennsylvania, the digger-wasp, *Discolia dubia*, has controlled this species for several years. In other localities perhaps other predators are largely instrumental in holding the pest to normal numbers; and the numerous bird enemies, especially the crow blackbird, are also very efficient destroyers. It has already been stated that the habit of the larva of coming to the surface of the ground after storms also serves as a means of repression, in that it exposes them to the attacks of agencies of various sorts, including man. Other atmospheric conditions are apparently inactive.

A BACTERIAL DISEASE.

A bacterial disease known as *Micrococcus nigrofaciens* has been recorded from the larva of this species, 96 per cent of the larvæ obtained from North Carolina in 1913 showing slight infection. So far as known, however, this disease exercises no appreciable effect on the numbers of the host.

MAMMAL ENEMIES.

Many instances have been recorded of the destruction of white grubs by wild mammals, such as foxes, raccoons, gophers, skunks, and chipmunks. The last two mammals mentioned and the opossum have been recorded as eating the grubs of this species. The much-abused mole destroys large numbers of the grubs on lawns and sometimes in gardens, but unfortunately it is difficult to determine which does the more damage to the lawns or gardens, the grubs or the moles.

[14] Specific identification by Dr. A. T. Speare, Bureau of Entomology.

BIRD ENEMIES.

Of bird enemies one of the most important is the common crow blackbird or purple grackle (*Quiscalus quiscula*). In the case of this bird 75 stomachs were examined and found to contain the green June beetle, and in several instances 7 or 8 were found in a single stomach. The constantly increasing numbers of this bird on the grounds of the Department of Agriculture where the grubs of this species were formerly very abundant has undoubtedly been one of the causes of the insects' decrease. Robins and crows frequent the same locality and have undoubtedly helped toward the same end.

Domestic ducks, according to Davis and Luginbill (45, p. 22), have been observed to seek the grubs eagerly, but, as a rule, gather only those which are on or near the surface of the ground. Chickens occasionally follow the plow and destroy these insects; but, so far as we know, domestic fowls are of very little value in the control of this pest.

During July, 1882, Mr. John D. Wilkins, Selma, Ala., observed that the mocking bird (*Mimus polyglottos*), the blue jay (*Cyanocitta cristata*), and cardinal grosbeak (*Cardinalis cardinalis*) were feeding on the beetle of this species. The kingbird (*Tyrannus tyrannus*) and cardinal grosbeak have been recorded by the Biological Survey as enemies of this species. The robin (*Planesticus migratorius*) and the yellow hammer or flicker (*Colaptes auratus*) have been observed attacking the grubs. Other species of birds which have been found by the Biological Survey to feed on either larvæ or adults include the woodcock (*Philohela minor*), broad-winged hawk (*Buteo platypterus*), screech owl (*Otus asio*), pileated woodpecker (*Phlœotomus pileatus*), red-headed woodpecker (*Melanerpes erythrocephalus*), chuck-will's-widow (*Antrostomus carolinensis*), nighthawk (*Chordeiles virginianus*), crow (*Corvus brachyrhynchos*), red-winged blackbird (*Agelaius phœniceus*), crow blackbird (*Quiscalus quiscula*), loggerhead shrike (*Lanius ludovicianus*), catbird (*Dumetella carolinensis*), brown thrasher (*Toxostoma rufum*), and wood thrush (*Hylocichla mustelina*).

METHODS OF CONTROL.

FOR THE BEETLES.

Remedial measures against the adults of the green June beetle have been tried, usually without success, by entomologists and other practical workers. In 1899 Dr. A. L. Quaintance, of the Bureau of Entomology, when working in the South, used poisoned

bait sweetened with sugar, but the beetles did not relish it. Others sprinkled poison on ripe fruit as a means of attracting the beetles, also without success. Prof. Henry Garman (36), Kentucky State zoologist, stated that hand picking for the adults seemed to be the only safe remedy.

If it were possible to destroy the beetles in larger numbers than has been done heretofore this would mean a great lessening in the abundance of the grubs, which, as we have plainly shown, are even more injurious than the beetles.

FOR THE GRUBS.

Numerous remedies which have been practiced successfully against the common white grubs (Phyllophaga) have been reported effective against the Cotinis grub, and again as useless. Years ago, according to Dr. L. O. Howard, an experiment was made which consisted of a modification of the bran-arsenic mash and met with success against this grub in a celery field.

Poisoned Baits.

There is little doubt that still better results might be obtained by using a grasshopper remedy, called the Criddle mixture, which may be modified to suit the grub under consideration. It has been used with great success in Manitoba. As originally used it consisted of 1 part of Paris green mixed thoroughly in 60 parts of fresh horse droppings, 2 pounds of salt to half a barrel of mixture being added after being dissolved in water. This is placed in a half barrel and drawn on a cart to the edge of the infested field, or one likely to be infested. The mixture is then scattered broadcast along the edge of the crop, or wherever needed, by means of a trowel or wooden paddle. The grasshoppers are attracted to it and are killed in large numbers by eating the poison.

A cheaper arsenical is white arsenic (arsenious oxid), used in the same proportion.

An application of poisoned bran mash was made at Norfolk, Va., November 18, 1914, in the field and under glass, but examination two days later failed to indicate results. It is believed, however, that if this remedy had been applied in September or October the grubs might have been killed.

Collecting and Hand Picking.

It has been shown repeatedly in different localities that after heavy rainfall these grubs are brought to the surface in large numbers, and it is not difficult to collect them early in the morning when

they are crawling over sidewalks and on unused ground. At such times they should be picked up and thrown into bags, barrels, or large baskets and promptly burned. Not infrequently they have been swept up from pavements and have received similar treatment. The same result may be obtained by flooding, which causes the grubs to appear at their exit holes in a few minutes.

Wherever it is possible to flood fields, such as lawns, celery beds, and similar areas, most affected by the grubs of this species, it should prove effective; in fact, one of our correspondents has reported that it is the only successful remedy that he has found on golf greens, and it should answer equally well for lawns.

Mr. Theodore Strohhaecher, of the Louisville Country Club grounds, stated to Mr. Davis that he had picked up as many as 3 quarts of grubs from a single putting green after flooding with water.

Collecting the beetles has been practiced to a considerable extent, and while this method may not be entirely effective, it is a means which should be adopted wherever practicable. Various methods have been adopted in different places. The Louisville Country Club pays the caddies for collecting the beetles, the work being done in the morning. At Hot Springs, Va., the golf club pays the boys so much a quart. Here they also used a trap which Mr. W. T. Bingham described April 30, 1914, as follows: "Wire netting was stretched on a frame 10 feet long and width of the roll (about 3 feet). This frame was set in a trough partly filled with water with a little floating kerosene. The beetles strike the netting and fall into the trough and the kerosene finishes them."

The time of collecting is of the greatest importance because of the habits of the females. They appear at daybreak and settle in the grass shortly after sunrise; hence, in order to destroy them, collecting must begin early in the morning. Also, collecting should start as soon as the beetles make their appearance in July, before they lay eggs, and should be continued throughout the month.

On an area of about half an acre at Portsmouth, Va., large numbers of grubs were picked by hand by following the plow (Pl. VIII, A). Some time later an application of kainit was made at the rate of 1,000 pounds to the acre. Less injury by the grub on this particular area was noted by the farmer. Undoubtedly the hand-picking had much to do with this success, but benefit from the kainit, while possible later on, has no direct noticeable benefit in destroying the grubs.

Carbon Disulphid.

Carbon disulphid has been used for many years with varying degrees of success for different forms of white grubs and other subterranean insects. Its cost, however, is somewhat prohibitive, and while it

may be effective on a small scale it is scarcely applicable for large areas. It has been pronounced the most direct remedy or insecticide employed experimentally by the cereal and forage crop insect specialists.

Since the burrows of this grub are open they are easily reached by the fumigant, the poisonous fumes of which are heavier than air. Carbon disulphid is injurious to grass and to plant life generally when applied direct and it is therefore recommended that a funnel be inserted into the holes made by the larvæ and beetles before pouring in the required amount of liquid disulphid, in this case about a teaspoonful to each opening. A large copper engine oiler forms an efficient injector for this purpose.

Caution.—Care should be exercised in the handling and use of carbon disulphid, since it is highly inflammable and the fumes, when mixed with a certain proportion of air, are explosive. There should be no fire of any kind, such as a cigar, near by when handling the liquid.

Kerosene Emulsion.

Kerosene emulsion was tested in 1888 by Mr. W. B. Alwood (14), when engaged in the Bureau of Entomology, on the Capitol grounds at Washington, D. C., where the grubs occurred abundantly on lawns. Application at the rate of 1 part of the standard mixture to 15 parts of water was made, and for several days afterwards the ground was kept freely soaked with water, with the result that not a single larva was found while the check plat adjoining contained numerous larvæ, only a few of which were dead.

Writing in 1901, Dr. L. O. Howard (32) stated that in experiments by Mr. Lull, formerly of the Bureau of Entomology, kerosene emulsion proved effective against such grubs as happened to be near the surface, but failed to reach those which were lower. Experiments with kerosene emulsion against the grubs of *C. nitida* conducted by others tally with the above observation.

Tests with Kerosene Emulsion.

Several experiments were conducted in the vicinity of Portsmouth, Va., with kerosene emulsion applied at the rate of 1 to 5 and 1 to 10 to cold-frame sash-growing parsley, using from 1 to 4 gallons of the liquid per sash. Tests were also conducted in the field, and in both instances the liquid was poured into the perforations made by the grubs, which extended from the surface of the soil to 6 to 10 inches below. At the time these tests were made the grubs were from one-half to three-fourths grown, and weather conditions were such that they worked at the depth mentioned above. It was not surprising,

therefore, that the results obtained did not fully substantiate expectations. Even at that stage of growth and at the depth mentioned, however, the liquid penetrated to the larvæ, and several grubs were found to have come to the surface, turned yellow, and perished. It is evident, as a result of these tests, that the success of kerosene emulsion as an insecticide where growing crops are concerned is dependent upon the stage of growth of the larvæ and the depth at which the grubs happen to be at the time of application. When they are young and work relatively near to the surface kerosene emulsion will prove more efficacious than when they are older and farther below the surface. In cold frames particularly, and in other instances where the grubs are known to be present and other methods of control suggested do not seem feasible, kerosene emulsion should be applied at the rate mentioned and be followed by a copious watering from a garden hose or sprinkler unless there are heavy rains.

EXPERIMENTS CONDUCTED ELSEWHERE WITH KEROSENE EMULSION.

Five additional experiments were conducted with kerosene emulsion with variable results. At Rosslyn, Va., an imperfect emulsion was made on golf links by using a barrel and a half of kerosene mixed with water and passing the oil and soap from one tub to another until an emulsion was supposed to be produced. This killed all the white grubs, but it also destroyed the grass. Still the experimenter was perfectly satisfied with the result. Other correspondents had the same experience, as usual not making a perfect emulsion. A correspondent at Saltville, Va., experimented with a combination of kerosene oil and castile soap, according to directions, but since an egg-beater was used in agitating the mixture, it was not properly mixed. It was applied *on the plants* with an ordinary water sprinkler, the grubs were killed, but about 75 per cent of the strawberry plants were injured.

Another experiment was made with the same imperfect emulsion which was poured *about the plants*. It killed the grubs *without* injuring the plants, as the leaves did not come in contact with it.

In experiments performed by Mr. Davis at Louisville, Ky., on golf links 80 per cent of the grubs in the treated area were killed by a single application of kerosene emulsion made at the rate of about 1 gallon to 6 or 8 square feet and afterwards thoroughly washed into the soil by copious sprinkling with water, a remedy which the Bureau of Entomology has recommended for many years for white grubs and similar forms of insects. An important point in the application of this insecticide is that it should be made as soon as the grubs become conspicuous, usually about the middle of September, or at about the time when they begin to crawl about on the surface of the ground.

PREPARATION OF KEROSENE EMULSION.

There are several forms of kerosene emulsion, but that used with fish-oil or soft soap has been found by years of experience to be the best.

Kerosene-soap emulsion is prepared by combining 2 gallons of kerosene, 2 pounds of fish-oil or other soap, or 1 quart of soft soap, with 1 gallon of water. Laundry soap, if dry, is shaved and dissolved in boiling water and then poured (away from the fire) while still boiling hot into the kerosene. The mixture is then churned rapidly for from 5 to 10 minutes, pumping the liquid back upon itself by means of a force pump and direct-discharge nozzle throwing a strong stream. At the end of this time the mixture will have become of the consistency of thick cream. Properly prepared, an emulsion will keep throughout a season and should be diluted only as needed for use. For most species of insects the staple emulsion should be diluted with from 10 to 20 parts of water. For this species a 10 per cent dilution has been found effective. In the preparation of kerosene emulsion a force pump is a necessity, since if not made according to directions a perfect emulsion is not formed. There is then danger of injury to the plants by the kerosene, as also useless waste of material.

After the emulsion has been applied it should be followed by a copious application of water from a hose in order that the insecticide may penetrate more deeply into the soil. In the preparation of kerosene emulsion other soaps than those mentioned may be used.

Where unskilled labor is employed, the operators should be carefully instructed as to the difficulties and intricacies involved in applying the emulsion that it may not be brought into direct contact with the plants, which might thus be seriously injured. Where laborers of the better class are not available, fish-oil soap and other soap solutions containing no kerosene are preferable.

Trapping Methods for the Grubs.

Three methods for trapping the green June beetle larvæ were used experimentally during the fall of 1914 on the farms of Messrs. Fred and George Richardson, at Portsmouth, Va.:

(1) By placing boards on the surface of the ground; (2) by setting flowerpots in the ground; and (3) by constructing V-shaped troughs in infested fields.

THE BOARD METHOD.

Boards 12 feet long and 16 inches wide were placed closely together on the surface of the ground in a field infested with grubs

(Pl. VIII, B). Early every morning the boards were turned over, and the larvæ which had worked close to the surface during the night were collected in cans or pails. Several dozen larvæ were usually found under every board thus turned, and after several days the boards were shifted to new areas. Since this method necessitates a large amount of hand labor it is somewhat expensive.

THE FLOWERPOT METHOD.

A severely infested field was selected in which parsley was growing in beds 6 to 7 feet wide and 200 feet long, with the plants in rows 6 inches apart. Three-inch flowerpots with the bottoms stopped with corks were set between the rows of parsley 2 to 3 feet apart in the rows, with the top of the flowerpot about a half inch below the surface of the ground, the soil being packed around the pot in a sloping fashion (Pl. IX, B).

The habit of the grubs of coming to the surface at night and crawling on their backs proved to be their doom. In passing a flowerpot the larvæ invariably fall in, and owing to the smooth surface and steepness of the sides they are unable to crawl out. Two to three dozen larvæ were usually caught in one of these small pots. A bed containing approximately 150 pots would in the course of several days trap from 2,000 to 3,000 grubs.

The redeeming feature in the use of this method is that the pots act as a permanent trap, and after a bed has been thoroughly rid of the grub the pots can easily be shifted to other infested fields. Moreover, the pots need not be emptied oftener than two or three times a week, or until they become two-thirds filled with grubs. In most instances observed, when larvæ are thus confined they destroy each other, thus preventing the pots becoming filled or affording the larvæ a means of escape.

In fallow fields or in spaces between beds, larger pots may be used. Experiments were conducted by using 7-inch flowerpots in the ground in the same manner as described for the small pots (Pl. IX, A). The advantage in the use of the larger pots is that the contents need not be emptied. Sometimes, when rains occur, the pots become filled with water, which drowns the larvæ.

This method is the only one now known that can be safely used in saving a crop that is planted in an infested field. Except for the outlay in obtaining the pots and the labor required in setting them in the ground, there is no expense attached to this method.

THE V-SHAPED TROUGH METHOD.

Trapping the grubs by constructing V-shaped troughs proved quite successful. (Pl. X; text fig. 7.) Owing to their size they can be

used only between beds of growing crops like lettuce, beets, parsley, turnips, celery, or in uncultivated fields. The method of procedure is to use boards 6 to 8 inches wide and of any length desired. These are placed in the ground in the form of a steep V, having the top edges of the board about half an inch below the surface of the ground. The boards can be made to overlap as shown in Plate X. The only precaution necessary is to block out any cracks or open places where the larvæ are likely to escape. At each end of the trough a keg or bucket is sunk into the ground and the larvæ that fall in the trough usually crawl along the bottom and fall into the keg.

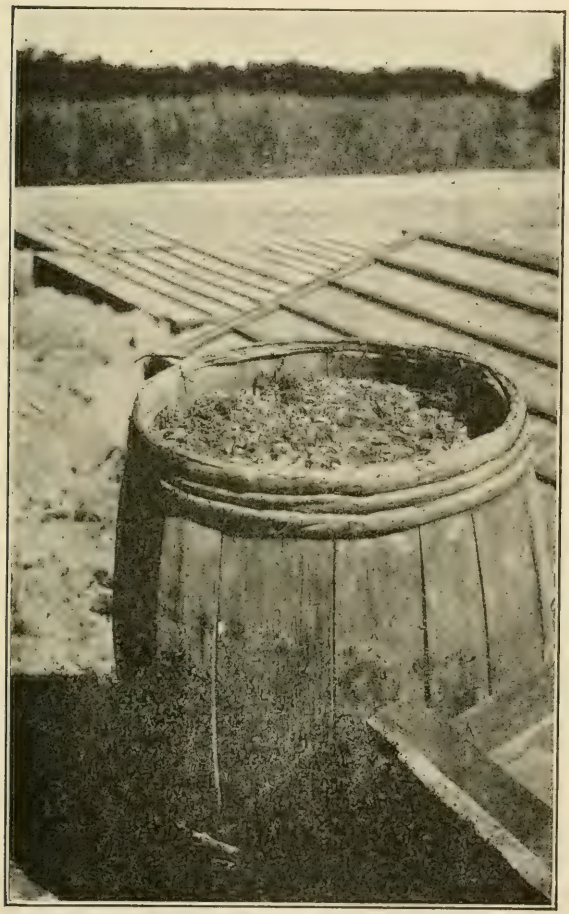


FIG. 7.—Barrel of grubs of green June beetle, estimated to contain 75,000 to 100,000, caught by trapping with troughs and flowerpots.

A trough constructed through the length of a field serves as a barrier, and grubs coming from either side of the trough are unable to pass without falling in. They are unable to crawl up the steep sides of the troughs; moreover, they seem to prefer to crawl along the bottom, with the result that they eventually fall into the kegs.

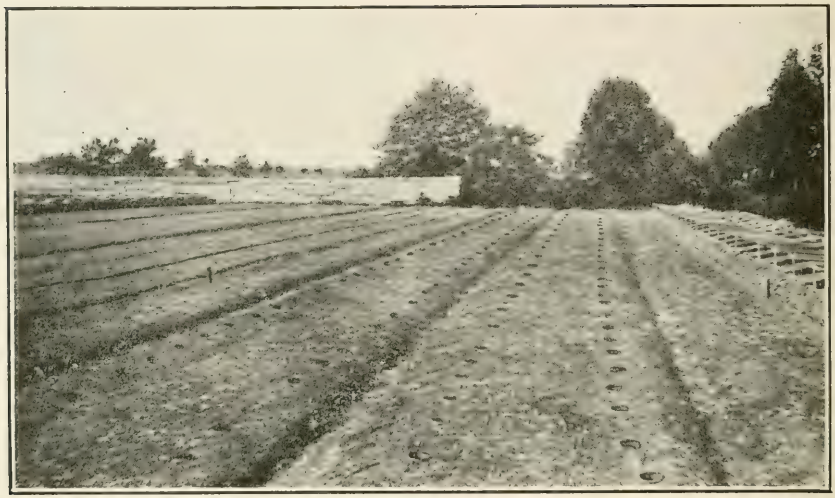
One of the large troughs thus constructed captured between 3,000 and 4,000 grubs in a single night. Estimates were made of the number of grubs captured on a 2-acre field containing 12 troughs, each 200 feet long, and within the short period of three weeks more than two 50-gallon barrels of grubs were trapped. Since there are approximately 400 grubs to each quart, and 200 quarts to a 50-gallon barrel, the number of grubs in a barrel would be 80,000, or about 160,000 grubs captured from a 2-acre field. (Fig. 7.)

A

B

CAPTURING GRUBS OF GREEN JUNE BEETLE.

A, Method of picking up grubs by following a plow; *B*, boards placed over beds for trapping grubs.

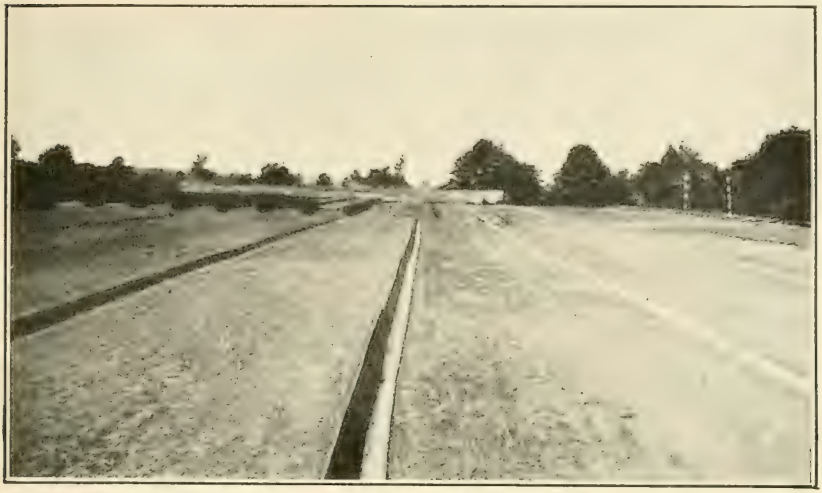


A

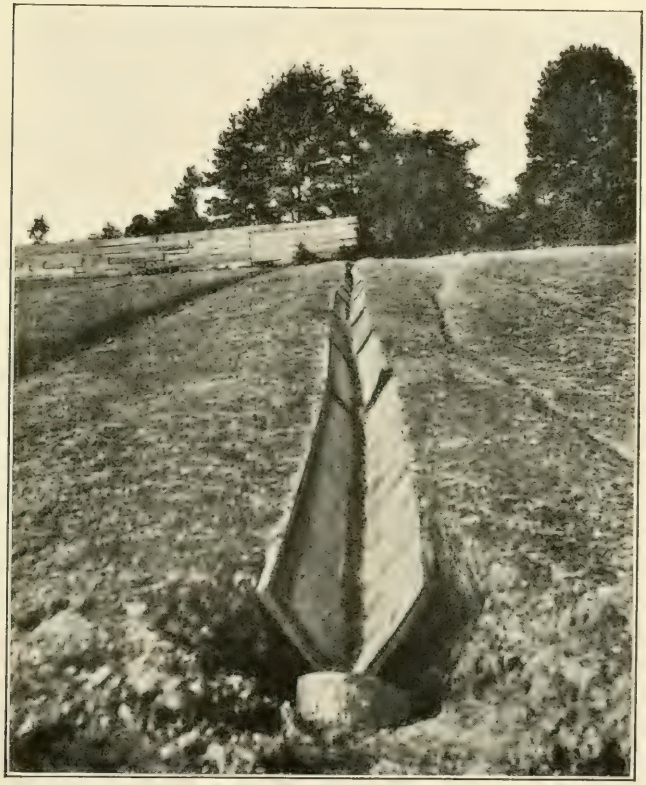
B

TRAPPING GRUBS OF GREEN JUNE BEETLE WITH FLOWERPOTS.

A, Field with 7-inch pots set about 3 feet apart; *B*, field in parsley with 3-inch pots set between rows, and 7-inch pots set in runways between beds.



A



B

TRAPPING GRUBS OF GREEN JUNE BEETLE.

A, Field set with V-shaped troughs 12 feet apart; *B*, the simple construction of a trough and keg for reception of captured grubs.

The adults of this species observed at Portsmouth, Va., during 1915 show a very considerable reduction in numbers, undoubtedly due to the large number of larvæ which had been captured in the fall of 1914.

SIMPLE TRAPPING METHODS.

The grubs have also been successfully captured in cold frames by the use of empty tomato cans. Mr. Trepass experimented on a larger scale on lawns and gardens at Glen Cove, Long Island, by setting boxes of the size of ordinary flats, about 3 inches deep, just below the surface, making the ground smooth around the boxes. During September he caught no less than 146 gallons, or nearly 240,000 of these insects.

Gas Lime.

Gas lime, which can be procured gratis for the expense of hauling, is well worthy of a trial. It should be applied in September or October for most vegetable crops; and for strawberry beds, potatoes, or vegetable crops, as soon as possible after the crop is made. One caution is to be observed, i. e., gas lime is dangerous to plant life; hence, it should be used experimentally on a small scale before employing it in entire fields.

INEFFECTIVE OR IMPRACTICAL METHODS.

A few remarks should be added in regard to what should be termed "ineffective methods"—remedies which have been suggested at times but which knowledge of the habits of the species show to be unworthy of trial, or which are impractical on account of their cost.

In 1895, Dr. J. B. Smith (25) claimed that kainit mixed with lime in the proportion of 1 ton of the former to 1,000 bushels of the latter proved fairly successful where tested in some parts of New Jersey. The high price of mineral fertilizers at the present time prohibits their use, otherwise they could be recommended in lieu of manure which, it is well known, serves to attract the female beetles for depositing their eggs.

Among the direct remedies which have been found most useful against the common white grubs (Phyllophaga et al.) there is scarcely one, with the possible exception of kerosene emulsion and carbon disulphid, which will be found effective against the grubs of this species.

Plowing.

Plowing seems inapplicable in the case of these grubs, except possibly in late May or June, when they are in the prepupal stage or have recently pupated and are consequently soft and delicate. The plow-

ing should be deep and when possible should be followed by thorough disking.

Neither spring nor fall plowing would be practicable when the plants are growing, and at other times the grubs penetrate too deeply, to the depth of 18 to 30 inches, after the crops are gathered, for the plow to reach them. Naturally if the insects are capable of existing in humus, or in land from which crops have just been taken, plowing in summer would be of little value.

Poultry and Hogs.

Poultry of such kinds as chickens, ducks, and turkeys, are useful destroyers of white grubs. Their use for this particular grub, however, would obviously be limited to their following the plow when the grubs are most active. Since the latter are not exposed to any extent except at night, fowls would not be of much value. Swine are also known to be exceedingly fond of white grubs, and when allowed the run of fields infested by Phyllophaga larvæ destroy great numbers of them. It is problematical whether it would be possible to pasture hogs in areas infested by the grub of this species with any appreciable effect.

Everything considered, it would appear that the utility of domestic animals is confined to such times as after rainfall or in connection with flooding.

Crop Rotation.

In regard to crop rotation it would be difficult to name a truck crop that could be profitably grown which this grub would not attack. Field and sweet corn, because of the woody nature of their stalks and roots, are not apt to suffer severe injury except when young. Cucurbits are not as a rule seriously affected by the larvæ, and in all probability pumpkin, squash, and melons are not so injured as to hinder growing them where these grubs are abundant. Onions are grown in rich land such as these grubs prefer, and as we have no record of injury it is quite possible that onions are distasteful to the grubs; the same might be true of pepper. Eggplant and potato, while occasionally attacked, are seldom reported severely injured.

In general it may be said that late crops, planted in June and afterward, will not suffer from this grub. All early seedlings, on the other hand, are subject to injury.

SUMMARY OF CONTROL MEASURES.

For Beetles.

Hand methods are the best to employ for capturing the beetles as they occur on fruits. They may be captured in buckets or similar

receptacles containing a little water on which a film of kerosene is floating. A boy passes along the plants and knocks the beetles into the bucket. Sprays are impractical.

For Grubs.

From experiments which were conducted during two seasons in tidewater Virginia against the larvæ of the green June beetle, the conclusion points to trapping as the best means of control in that region and probably in most others.

Trapping.

Flowerpots and V-shaped troughs have proved the most successful and inexpensive methods. Their simplicity and cheapness are factors in their favor. They also serve as permanent traps until a certain area is cleared of all grubs, and they can afterwards be shifted from one field to another. Where a crop has already been planted, the flowerpot method is the only one that can be safely used. In other situations where a trough can be placed, this method is the most advantageous and inexpensive.

Kerosene Emulsion.

Experiments with kerosene emulsion indicate that success can be obtained when the grubs occur within 2 or 3 inches below the surface and when they begin to crawl above ground. In large areas the application is expensive but in more limited areas, as under sash, good results may be obtained with the emulsion at a strength of 1 to 10, using 3 gallons of liquid to a sash. The cost is approximately 2 or 3 cents a sash. There is no injury to foliage if carefully applied; parsley, a delicate plant, has not been harmed in the least.

Unless directions are carefully followed for the preparation and application and necessary precautions taken, kerosene emulsion is apt to fail. This, however, does not detract from the fact that properly applied it can be used quite successfully.

Other Remedies.

Poisoned baits such as have been used successfully against cutworms and grasshoppers have not been given a thorough test but are worthy of a trial. The same applies to lime and gas lime, because they have proved valuable against the common white grubs.

Collecting the grubs by mechanical measures is also of value, but, everything considered, is not as good as trapping measures which have been thoroughly tested.

Carbon disulphid will kill the insects and has been used successfully by Davis and Luginbill (45, p. 25) on putting greens, but it has not been thoroughly tested on truck farms. The same applies to the rotation of crops.

It should be remembered that other remedies which are applicable for common white grubs, such as plowing and the utilization of domestic animals as destroyers, are ineffective under ordinary circumstances.

GENERAL SUMMARY.

The green June beetle is a common and well-known insect in the eastern United States, from New Jersey and southern Illinois southward. It occurs also commonly on Long Island and in southern Connecticut.

It prefers a sandy or sandy loam soil, richly incorporated with humus, and for that reason is troublesome in many trucking sections of the country, particularly the sandy coast regions.

The larvæ, or grubs, injure vegetables of many kinds, particularly celery, parsley, lettuce, beets, turnips, carrots, parsnips, collards, sweet corn, and peas and beans in the seedling stage.

While there is evidence that the larvæ injure certain of these plants by severing the roots and young stalks, major injury is due to the upheaval of the soil around the plants, which disturbs the root system. Their constant burrowing near the surface in the fields and garden loosens the earth, causing it to dry out, which greatly retards and injures the plants' growth.

The grubs are the cause of extensive trouble on lawns and golf greens and do injury also to alfalfa, oats, and some other crops, including ornamental plants.

The beetles injure fruits of various kinds, especially grapes, peaches, apricots, and figs, and growing ears of corn, and feed also on the sap of trees.

There is only one generation or brood of this insect a year.

The beetles occur from the middle of June to September and are to be seen in greatest numbers from the middle of July to the middle of August, these periods varying somewhat according to location and temperature.

Eggs are deposited from 6 to 8 inches below the surface of the soil and hatch in from 10 to 15 days. After the first molt the larvæ feed nearer the surface of the soil. Larvæ become three-fourths grown by late fall, having molted twice. With the approach of cold weather, they go deeper into the ground—8 to 10, and even 30, inches below the surface—and continue inactive during the winter, except in mild winter localities where the grubs may be active at any time during warm spells. Early in spring, depending on locality,

the grubs again become active until the middle of May, when the larva makes a substantial cocoon, in which it transforms to the pupa. The pupal period lasts 15 to 20 days.

Many natural enemies of the grubs and beetles, such as birds and certain internal insect parasites and predacious insects, materially aid in the reduction of the pest. Of these, blackbirds, robins, and a large digger wasp are the most effective.

For the control of the grubs in cultivated fields, trapping with flowerpots or V-shaped troughs are the most successful. Poisoned baits, prepared in the same manner as for cutworms, scattered on lawns and cultivated fields late in the evening, are also valuable. Kerosene emulsion is an excellent remedy. Flooding is of value on golf links and lawns.

Hand methods are employed for capturing the beetles as they occur on fruits and for the larvæ on lawns and golf greens.

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